A PHYSICAL AND ECONOMIC GEOGRAPHY OF SIND

(The Lower Indus Basin)

By

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SINDHI ADABI BOARD

Sind Assembly Building, Bunder Road, Karachi.

Tilak Incline, Hyderabad Sind.

Published by
Mohammad Ibrahim M. Joyo
Secretary,
Sindhi Adabi Board,
Sind Assembly Building,
Bunder Road, Karachi,
Pakistan.

FIRST IMPRESSION 1959.

Printed by
Ahmed A. Jivaji
at Aage Kadam Printery,
South Napier Road, Karachi,
Pakistan.

To
MEHER AND FRANEY

FOREWORD

My scientific career commenced with the study of Sind, and its geography now forms part of my life work. Ever since I came to Karachi in 1920 to serve in an educational institution, I have endeavoured to explore and to understand Nature and natural phenomenon in this part of the world, whether it was by going through the records and memoirs of the past or by travelling across the countryside. The geography and geology of the lower Indus basin into which Sind naturally falls, have always been found to be appealing and illuminating to me. Such a knowledge is necessary not only for understanding the secrets of Nature but also for making plans for the improvement and advancement of the Country.

Physical geography, based on geology, is necessary for understanding the human and economic side of our problems. This monograph therefore deals with the major physical aspects of Sind - geology, physiography, climate, soils, natural vegetation and animal life. The vagaries of the Indus river - the major artery of Sind - have been specially treated in some details and the economic resources have been appraised and pointed out. A chapter has been added to show how far the economy of Sind depends upon natural conditions. Besides this, a chapter on "The Lines of Communication in Sind" will be found useful in an economic appraisal of Sind no doubt. It is hoped that this monograph will be found useful not only by students and the general Public, but also by planners for the future.

Lastly, a reference has been made to the development of the Indus Valley Culture derived from all these human activities. The history of Sind is long and varied. Although political changes have frequently taken place, the physical

environment has remained more or less constant. Nature plays her part worthily in any region, if man co-operates with her and helps her in the development of the natural resources. Post-partition conditions have left Sind within the One Unit of West Pakistan, and it has been subdivided into two parts, Hyderabad and Khairpur,—the former comprising districts in the south and the latter those in the north. Karachi, the Capital of Sind before Independence together with 54 *dehs* or villages in its neighbourhood now forming Greater Karachi, covering 566.8 square miles, has been separated from Sind under Federal Administration. But however much the political boundaries change and re-change, Sind remains essentially as the notable physiographic region of the lower Indus basin, - as that of a fertile and aggraded Indus Valley, a growing delta and a comparatively dry zone, lying between two prominent deserts of Baluchistan and Rajputana. Sind's geographic function remains the same as before.

True to its history and progress of human settlement, Sind, again, has given shelter to refugees entering it from all directions. The problem of rehabilitation of the refugees since the event of 1947 and subsequent years can be solved satisfactorily after a critical land-use survey in this region.

Parts of the present monograph were written long ago for my Sind Thesis and the references are given at the end. Much of the information and data given in the different chapters were originally published in the form of research papers in scientific journals before Partition. They form part of my thesis on the Lower Indus Basin for the degree of D. Sc. They have been revised and brought up-to-date as far as possible. Some relevant maps, charts, graphs etc., have been added to illustrate the subject matter. For the guidance of students and research-workers, a full list of my

publications, and unpublished theses of my research students belonging to the Universities of Bombay, Sind and Karachi has also been appended.

I am greatly indebted to Professor E. C. R. Taylor, Emeritus Professor of Geography in the University of London, who inspired me to make a study of Sind; to Dr. D. N. Wadia of the Geological Survey of India, at present working in the Atomic Energy Division of the Government of India, who encouraged me in my research; to the many officers of the then Government of Sind who helped me with the necessary data; to Professor Mohammad Ikram-ur-Rehman M. A. (Alig.) M. S. (Wis. - U. S. A.), Chairman Department of Geography and Geology, Urdu College, Karachi for preparing original maps and diagrams for the book; and to the Sindhi Adabi Board, who have given me an opportunity to draw upon my original research papers and to produce this monograph in a comprehensive volume.

May Sind flourish for ever!

— Maneck B. Pithawalla

Karachi,
20th November, 1955.

mentioned," and appropriated them ... in [illegible] pertaining to the Historians of Ancient Sind and Karachi have been appended.

I am greatly indebted to Professor A. F. R. Wadia, the then Professor of Geography in the University of Bombay, who inspired me to make a study of Sind; to Dr. D. N. Wadia of the Geological Survey of India, at present working with the [illegible] Division of the Government of India, who [illegible] for the many [illegible] of Sind who [illegible] me with. The [illegible] Professor Mohammad [illegible] M.A., M.S. (Wis.) (U.S.A.), Chairman Department of Geography and Geology, Urdu College, Karachi for preparing of maps and diagrams for the book; and to the Sindhi Adabi Board, who have given me the opportunity to [illegible] to publish the monograph of [illegible] volume.

May Sind flourish for ever!

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Karachi.

20th November 1955.

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(The Lower Indus Basin)

CHAPTER I

INTRODUCTORY

THE CHIEF AIM of this monograph is to present, in the first place, an analysis of the environmental conditions of the province of Sind, which nearly coincides with the lower Indus basin; and then a geograpical synthesis, showing the association of man and Nature in the same region. Such treatment should supply basic information for many workers in the field, viz. the agriculturist, the business men, the industrialist, the sociologist, the administrator and the politician, and stimulate all of them to find some correlations between their work and the environmental field.

It is now a recognised fact that geographical factors influence man's actions as well as his character, and that the history of a country is to a certain extent related to its geography. The directions taken by movements of population, the establishment of human settlements, the marches of armies along certain routes and giving battle at convenient points, the growth and decay of an empire, the obstacles or facilities afforded by a province or region in its political, economic or social advancement in different directions, and above all, the destruction, supersession or assimilation of one culture or civilisation by another, have much to do with the *geographical features* of the area. The histories of ancient Iran and its world-wide empire, of Crete and of Sparta, of the Greek city states, of the Egyptian, Roman and Byzantine civilisations, and most recently, of the Abyssinian Empire and British Common-wealth are all dependent on geographical conditions of the lands. Not

only this, but the trend of the history of one country is similar to that of another in this respect. Thus, in the birth of a new pattern of state, in its growth and advancement through the highways or waterways, inland or open sea routes, and in its death due to over-expansion or moral deterioration, the physical factor invariably counts. World power at any time in the history of mankind can be resolved into (1) the place, which must mean the geographical factor, (2) the time, which must be ripe and opportune, and (3) the man, who must be ready to utilise the opportunities.

This is more true of the Indo-Pakistan Sub-Continent than of any other country in the world, because its civilisation is exceedingly old, and its geography is in many respects unique. The physical features of the Peninsular and Extra-peninsular areas, the roaring hill torrents, the snow-fed or rain-fed rivers and placid streams, the variety of surface contours, climatic conditions, soils and vegetation, forests, desert lands and deltaic swamps, the work of external geological agencies on rocks, and, above all, the most convenient open fields of the Indo-Gangetic plain, which is not only the most populated region, but also the most contested battleground in the old Indian Empire, have all had a marked influence on its history. In fact, the whole growth of this land has been influenced by its geographical conditions. There was never a political upheaval nor a social or economic collapse recorded, which had no connection with the natural conditions of the land.

So also the principle of historical geography is followed in the formation of a connecting link between the geography and history, of a region like Sind. This principle is to recognise how it has been evolved by nature and by man, how man placed in it with its peculiar physiograghy, climate, etc., performs his duties, what houses he builds, what food he eats, what the sources of his water-supply are, what roads he makes, what fields he cultivates by draining wet land or by cutting fresh canals and

what settlements he establishes from time to time and from age to age.

THE SUB-CONTINENT AS A WHOLE

In the sub-continent, from the earliest time, all historical movements have been affected by its peculiar geographical conditions. The following historical factors, i.e., factors contributed by its history, have been well marked:

1. The first and foremost historical factor is "passivity within and activity without". Foreign invaders have had the largest share in its history, and it appeared as though the land was destined to be ruled over by foreigners. The chief reason is that the country, though in itself-selfsufficient, yet through its few seaports in the south and its fewer mountain passes in the north, attracted greedy or needy foreigners. While the impenetrable wall of the Himalayas and the N. - S. strike of the Burmese Yomas have entirely prevented foreign aggressions from these directions, the Khyber and the Bolan passes have influenced the past history of the country most and have facilitated ingress.

2. The neighbourhood of the dry plateau of Iran has placed it always in a critical situation. Dearth of food and water, and scanty habitable land have driven the highlanders periodically into the fertile valleys of the Indus and other rivers. This was also possible, because the lower slopes of the intervening mountains striking east and west, fall gently into the plains below.

3. The sea coast, though uninviting owing to the scarcity of natural harbours, has afforded convenient landing places to daring European sailors. Calcutta being its most attractive port on account of the fertile hinterland and having a navigable river, it was here that the British opened their first political innings against the hordes of untrained Indian soldiers. With only country crafts the natives could not venture on the open sea, and hence the development of Indian harbours and trade

could commence only after the British took possession of the land.

4. The geographical position of the ancient capital of the sub-continent, Delhi, is the most significant in the country. It lies within the very gateway of the sub-continent, between the high Himalayas on one side and the Aravallis on other, and across the two important valleys. A battle on the threshold of the city, viz., Panipat, must be fought before a conqueror could march successfully onwards. Whoever was the conqueror of the city of Delhi automatically became the conqueror of the whole country.

5. The climatic conditions of the sub-continent are also varied. They have made or marred the fortunes of many conquering races. Few battles were fought in hot summer or in the rainy months; winter was the most convenient marching season.

6. The people are heterogeneous in character, because the different local physical conditions, e.g., uneven distribution of food and water, have made them so. Foreigners came but they went back, leaving a sprinkling of aliens behind. Conversion played a great part in the life of Hindu India. Changes in dynasties meant no change in the life of the people or the system of government. There are castes and sub-castes differentiated by local peculiarities of structure, soil and climate. They are, besides, a people contented with the products of the land, soft people of the soft soil, having sufficient solar energy, unambitious, leisurely and, therefore, absorbed in religious practices and philosophy.

7. Such a mixture of races, different castes and creeds, speaking different languages, and having peculiar customs and manners of their own, has not always been successful in internal administration. Because there was difficulty of communication in a land of such a heterogeneous character, even the government took its form from its geography. Each clan or district

became autonomous and governors who were deputed by the sovereign head to its distant parts became independent of the Central Government in no time. A weak central power at home stimulated the suction of foreign aggression through the valves of the mountain passes, and often the different native states became despotic and therefore ephemeral.

Such lack of unity has been the root cause of its political bankruptcy in the past. Its physical conditions have much to do with this. Says H. B. George: "India has been through a long history a geographical expression having no political unity to correspond. It has become a political whole though with limits not coinciding very closely with the physical boundaries. In spite of its mountain defences, it has been invaded through the passes by many various peoples, before and during recorded history, and its inhabitants are by no means alike in race". This statement is corroborated by another student of historical geography. "India from the second century before the Christian Era to the date of the first European settlements, had been subjected to successive waves of invasion. Each of these invading armies entered from the north-west into the Indus Basin and gradually penetrated into the heart of India, but all of them lost something of their first impetus before they completed their object. This fact accounts largely for the many races that make up the population each with its own distinctive character, and yet each stamped with a common seal. Not one of these peoples was sufficiently strong to conquer the preceding invaders and impose their own form of civilisation on the country". 1

THE INDUS BASIN

Unlike the Ganges Valley, the valley of the Indus, though a "good starting point for an invasion of India," took some time in being conquered by the British, as it lay in the dry region and its river and coast were not so attractive. But it was among the earliest to be invaded by the people from across the

Persian Gulf and the N.W. Frontier, and became a most important factor in the birth and growth of the nation. Here the mountain passes placed the resources of the Indus valley at once at their disposal. The interaction of different races in the province of Sind, though restricted, has made its history possible. To the Persian and Vedic Aryans from the North it owes its language and other institutions, while to the Sumerian and Semitic peoples from across the sea, it owes its civilisation and mode of life. There was also the spirit of religion in Sind conquests, conversion and assimilation of culture being very freely practised. The attacks on the land being periodic, the various kingdoms that were formed, were not lasting. They were for the benefit of the rulers and not the native farmers. The system of government was not changed, but was left in the hands of the natives, the defence of the province only being taken over by the conquerors. As it was all a plain, no prolonged war was required; a single battle was enough to annex the province and to establish law and order, e.g., the battle of Miani, like that of Panipat, opened the entire Indus river to peaceful commerce through the port, while at the same time, the way was clear for them to approach Ranjit Singh in the Punjab.

Throughout the long course of its history, Sind has had its vicissitudes. Its control of the Indus, its conquests, governments, trades, all have undergone changes; its prosperity, eclipsed for a time, was revived again and again, and its people have gone through different stages of civilisation; but its system of agriculture, on which its very existence depends, has remained practically constant. Even the dress of the *Haris* and the shape of the bullock carts are as of old. Yet, change is the order of the day even in the scope and extent of agriculture. If neglected, even the river is liable to change its very course, and tracts of land, if not properly irrigated, become barren. In view of all these factors, it is necessary to study the outstanding

geographical features of Sind and to establish a relationship between them and the history of the land.

OUTSTANDING GEOGRAPHICAL FEATURES

Position and Topography: Sind is at a cross-road of cultural movements by land and sea and air. In size only about a thirty-third part of the sub-continent, it has been an antechamber for its many crores of people and a stepping stone to the main land. It is between the arid plateau of the S.W. and the flood plains of S. E. Asia. It lies largely in the delta of the lower Indus basin, with three of its sides essentially connected with areas of marked geographical contrasts. On the west, it rests against the slopes of the barren and monotonous Kirthar Mountains bordering on the Iranian tableland, down which descended many thirsty marauders, tribes and races escaping from the climatic, social or political pressure of their lands. Towards the east, it gradually passes into the great desert of the Thar, beyond which lie the further barriers of the Aravalli Range and the chains and forests of the Vindhyas and the Satpuras. As the base of the deltaic triangle it has the Arabian sea-board, receiving from it what it can offer, while its narrow apex penetrates into the plains of the Five Rivers in the north. It is about 360 miles long from north to south (between Lat. 23°35' and Lat. 28°30' N) and nearly 275 miles in its extreme breadth (175 miles average), thus covering nearly 52,994 sq. miles.

It has a flat low-level country topography with some hills in the distance. Its soils are deltaic valley soils, with sands more and more in prominence as we go down to the sea-board. Its rocks are marine, with plenty of proofs of the presence of a sea which once lay between the two hilly regions of geologically different formations and age, viz., the Kirthar and the Aravallis.

Passage Ways and Trade Routes: This low and very fertile valley was sought by people living in comparative poverty in

the surrounding dry regions. Immigration and settlement have been common in this region, from the very beginning of human history.

The complex folding of the Hindu Kush Mountains have afforded few openings between Central or Western Asia and the sub-continent. Being nearest to the Asiatic centres of civilisation, the Khyber Pass, however, has been frequently utilised by travellers and invaders; but a much less difficult route lies through another notch in the Highlands, the Bolan Pass, situated within the simpler folds of the Suleiman-Kirthar Ranges and leading through Kandahar and up the Hari Rud to Merv and Turkistan. This is the old Quetta-Seistan trade route which was also followed by Alexander's troops on their return journey. There are other notches in the Kirthar Mountain, leading across the longitudinal valleys of Makran into the historic trade routes of the Central Persian, Bampur-Kalat-Gandava route, through the Mula Pass, and the great Arab trade route, viz., Tiz-Lasbela-Debal route. Besides these, the sea route to Sind was open to those who traded with the East through the Persian Gulf, and with South India.

Critical Position: This combination of the mountain passes in the west and the inlets of the southern coastal corridor has incidentally placed the whole province in a very critical position. With the political rise and fall of the Iran plateau, has risen and fallen the whole of the Indus basin. As there are no natural harbours, the sea coast being shallow and unbroken there was no great sea trade in historic times. Yet the numerous inlets of the Arabian Sea, which coincided with the outlets of the Indus, helped Sind to admit sea-faring people from far-off countries such as Europe and Mesopotamia, as well as the neighbouring lands of Gujarat, and Cutch and the Deccan. Many of these immigrants came, settled for a time, and, then, as time went on, their influence passed further inland.

Sind is devoid of useful minerals except salts, and so metals

of all kinds have had to be imported from the hilly regions of Afghanistan, Baluchistan, Makran and Iran on the west, and the Aravallis and other mountains in the east. Thus, intercourse between its neighbouring parts has always been maintained.

Sind - A Gift of the Indus: Sind, indeed, is a gift of the Indus. This age-old river is the very life of the land. It is like an enormous oasis in the desert region. It almost bisects the province, and throwing its waters on either side, embraces as much of the cultivable land as possible. Its length in Sind with all its windings is 580 miles, about a third of its total length, and nearly 380 miles as the crow flies. Lying, as Sind does, almost outside the influence of both the monsoons, this unique river has been the sole means of support, and to some extent, also of communication for the people until the introduction of the N. W. Railway in the nineteenth century. All the defects and irregularities of rainfall are made good by the river, while it, in its turn, depends for its wealth of waters, upon the snows of the Himalayas, which melt early in summer, and rains which fall on its upper reaches during the year. Floods, too, are caused by occasional glacial disturbances, such as the Shyok, or by cyclonic storms, and the waters of the river often break through the protective embankments or *Bunds* into the surrounding lowlands.

The two unproductive lands on its sides, viz., the barren hills of the Western Highlands, and the sandy sea of the Thar Desert, have accentuated the geographical feature of this rich valley. They have emphasised its singular character, so much so that the river, has not only given its own name to the province of Sind but also to the land of Sindhustan. Sind's perennial water-supply, rich productive soil and geographical boundaries attracted many a people, who made their homes, highways and agricultural farms within the area. Even sacred hymns were dedicated to the Indus waters by the Rig Vedic poets, who lived in the upper parts of the valley. On the west side, the

piedmont zone of the hill slopes has formed an ethnic frontier between the plundering hill men and the peaceful agricultural races along its banks. The Thar desert, on the other side, is not altogether arid, as now and again it receives a small fraction of the monsoon rainfall. It is not an insurmountable barrier, therefore, between the cultivated fields of the Indus Valley and the semi-arid Rajputana hill tracts, while the passage of the Indus water through the Punjab has enabled the two provinces, the upper and the lower Indus Basins, also to preserve their intercourse throughout all times. The Indus, again, has a fall of over 10,000 feet at Gilgit and so with this added energy, it carries rich silt, sand and gravel an enormous distance. These are deposited in the valley and the deltaic region, as the speed of the stream is reduced. Alluviation is more or less complete in the valley of the Indus. Consequently, the river does not flow north and south directly but takes a deep S-shaped curve here within the limits of Sind and thus adds more and more to its cultivable lands. The rocks of Sind again are Tertiary limestones, sandstones and shales. They are soft and are easily eroded in flood times and by weathering at other times, adding considerably to the soils of the region. The river Indus has its rapids and giratory currents, shifting sandbanks and violent swells in the monsoon season. It is, therefore, as destructive as it is productive. The great compensation is its exceptionally rich silt, which renews the fertility of the soil every flood season, and thus the granaries of Sind have always been a lodestar for the semi-starved nomadic tribes of Asia.

Many-sided Onslaughts: Lying on the fringe of old civilisations with their centre of gravity in Central Asia, Sind has experienced frequent onslaughts of invasion. These again were periodic owing to climatic changes, accumulation of sand, failures of rains and crops, congestion of habitable areas and the rising of leaders of genius on the central plateau.

Stream of Movements: The earliest settlement, discovered

so far on the Indus, was on its right bank in the Larkana District, viz., Mohan-jo-Daro. The leaders of the Indus Valley culture appear to have much in common with those of Mesopotamia and Sumeria. Further, the aspiring Vedic and Persian Aryans, Greeks, Scythians, Arabs, Moghuls, Afghans, and Baluchees from the west, and the Rajputs, Cuchhis, Kathiawaris and Gujaratis from the east and the southeast, all took their chance and contributed their share in a virtual mingling of races that has gone on for many long centuries in the province.

Land of Unstable Drainage: And yet the land of Sind is unstable, because its natural drainage is such. The people in the region always preferred to settle down where there was a plentiful supply of water for their sustenance. But unfortunately for them, the Hakra river, towards the east, the parent of the Eastern Nara, dried up and the Indus never kept its channel in the same position for long. Its courses throughout all times are numerous, alterable and unstable. For this reason Sind, could not have one definite capital throughout the ages, but several chief towns, which rose and fell till ultimately the British Government established its headquarters at the comparatively good harbour at Keamari. Even here the fate of Karachi hangs on the problems of its water-supply, as its population increased year by year. This uncertainty of water-supply has been the cause of great troubles in Sind; it led to uncertainty of crops, which in its turn led to uncertainty of life or luck, until it formed part of the very nature of the Sindhis.

Growth of the Delta: Another physical fact worth noting is that the Indus delta has been continuously growing. Though the navigability of the river is diminished thereby, it gives more and more cultivable land to Sind, while at the same time it has thrown many a prosperous port into the background. This delta shows a distinct southwestward tendency in its growth and the small seaports at the numerous mouths of the Indus also drift westwards. Karachi, though not actually on

this great river itself, came into prominence after the British conquest of Sind, due to its accessibility from the high seas and the hinterland of the Punjab. This, coupled with the fact that a whole river has been lost in the desert region, made the population of Sind drift from the left to the right side and from the north to the south even in historic times. The advancing delta also enhanced the value of habitable and cultivable land in the valley proper. Downstream, river navigation could easily pass into sea navigation and the first geographical survey of the Indus was actually made by Skylax under Darius the Great, in whose footsteps the Macedonian conqueror, Alexander, followed. The latter sent his own navy, under Nearchus, down the river to the Persian Gulf. It was only the S. W. monsoon trade-winds later in the season, that prevented his followers for some weeks from returning home by sea and caused a mutiny among them.

A Sea of Sand: Though the mainstay of Sind is its water-supply, the nature of the country has tended to shift its water channels from side to side. The dry areas are, therefore, strewn over with sand. The sandhills have played their part in covering up cultivable soils, flowing streams and flourishing cities, and even an occasional earthquake, or the river's own silting up, has helped the river to turn a corner, so to speak, at times during the course of centuries. The result is that though the Indus, like the Nile, is classical, there are few classical towns left on its banks to-day, e.g., Bukkur and Sehvan, in the course of nearly 400 miles. Beneath the desert sands and barren soil they lie buried and archaeology has done but little to uncover them and their golden treasures of pre-historic days.

Sind as a Separate Province: Owing to the continuation of the Indus valley northwards, any political or social upheaval in the Punjab was shared also by the lower part of the region. Unlike Rajputana with all its intricate mountain fastnesses, Sind lay exposed to the conquerors of the Punjab, Aryans,

Persians, Greeks, Afghans, Moghuls and others, Akbar having actually annexed it to his Indian Empire in 1591 A. D. It was partly due to the difficulties of moving upstream that the sea-faring conquerors of Sind, such as the Arabs, could not go beyond Multan into the interior and their rule did not endure for more than three centuries or so. So also the physical peculiarities of the growing delta proved an obstacle to other conquerors. Moreover, this aloofness of the province made it a place of refuge for persons of royal families, such as Humayun, Shah Jehan and Shah Beg Arghun. This unique geographical situation of Sind proved a stumbling block also to settlers, like Rajputs, Buddhist, Kuchhis, Makranis, Sakas, etc., and sooner or later and often during the long course of its history, it burst into a separate province. It is noteworthy that while at one time the ancient Hindu Kingdom of Sind extended far up to the happy valley of Kashmir, it often shrank into its own in later times.

No rulers from far-off Sumeria, Baghdad, Kandahar or Delhi could keep it long under its control for the same reasons. Its natural features invariably exposed the whole of its interior to foreign attacks and aggressions. Even within the limits of Sind itself, factions and autonomous districts were common, while sub-kingdoms rose and fell in turn. Its physical isolation is also responsible for its non-participation in the Sepoy Mutiny of 1857, except through the intrigue of one man called Daryakhan, though it had, then, been newly conquered by the British on account of its key position on the borders of the growing Indian Empire.

A clearing House: Sind, then, can be called a clearing house of cultures for thousands of years, which it helped to pass on to the whole country. Perforce, there were religious conversions, inter-communal marriages, mixtures of ideals and even of religious doctrines. The Aryans were the first to come into conflict with the Indus Valley dwellers. The language, Sindhi

is itself a proof of an intercourse between the different tribes. Sikhism and Sufism are its other peculiar products. The Sindhi soil is a common bond of union, and the majority of the population are farmers, Hindus as well as Moslems. Even among the Harijans of Sind there are Moslems and Hindu sections, both belonging to the backward classes. So also the Arab governors, in the eighth and ninth centuries A. D. remained farmer-generals of their days. The village community of cultivators is the human unit in the province even to-day.

Prosperity and Adversity: Prosperity made the people of the Province physically weak and lazy. They always yielded to invaders and soon succumbed to foreign rule and influence as a matter of course. Even the rigorous climate, with its excessive heat in summer and cold in winter, left its marks upon the physique of the natives. Fresh blood following on fresh onslaughts, helped to restore the balance for a time. Not quite truly can we say it is an "unhappy Valley", as it has itself, while under pain, given to the mainland the best that it can give, open always to fresh reception and impetus to settlement and renewed mingling of cultural and civilizing forces.

Nature helped the land at one time to become prosperous, and settlements grew where cultivation was plentiful; but because of the uncertainty of water-supply, if there is any land, which gives us an idea of a futile human life on earth, it is here.

As early as 1843, Postans drew a similar pictures:— "The geographical features of such a country are very peculiar. Towns, once of commercial importance, are now no longer valuable for the objects of traffic; the facilities lost; ports which were resorted to for the whole trade of the Indus are ruined and abandoned; and portions, at some periods, cultivated are desert tracts. The natural sloth of the natives of Sind induces them always to choose their localities near the river, where subsistence is easily obtained, and in this way they often suffer; for whole villages are in the course of a season swept away by its torrent.

The noise of the falling banks of the Indus when heard upon the stream during the calm night, resembles the constant discharge of distant artillery."

A land of Contrasts: What, then, has contributed to the prosperity or otherwise of such a province? The answer is, it is a land of contrasts:

(1) *Partial exclusiveness*: It is excluded from the neighbouring lands, on account of the Kirthar mountain, the sea and the desert, and yet all these barriers have provided narrow and restricted passages for conquest, commerce and culture. This has prevented stagnation and given stimulus for growth within the province from the eastern and western countries.

(2) *Severity of climate:* The weather charts of Sind afford a most interesting study to climatologists. The extremes of temperature in summer and in winter, in north and in south Sind, and even between day and night are very great. The rainfall is unstable and variable, and winds change their directions almost every season. Cyclonic storms of rain are not uncommon. It is also an open question whether there has been any real climatic change in the region, and Sind exprienced wetter years in the past or not.

(3) *Awkwardness of the Indus:* The only hope of the people in their struggle for water to-day is the river. But this stream is a very awkward one. There is not an inch of ground, so to say, in the valley, which has not at one time or another been flooded by the Indus and then discarded by it. Then again, a whole river - the Hakra, has been lost in the eastern part of Sind which is now turned into a desert.

(4) *Fertile but thirsty soil:* The soil of Sind is so fertile that it has been a great inducement for people to settle in the land, to attack, possess or plunder it, now and then. The history of Sind shows that many of those who came to fight were induced to settle down, at least for the time being, and to till the soil as

Haris. Irrigation is as old as man and the balance of power between the environment and man is in favour of the former in the hilly and desert areas, while it is in favour of man in the region of the valley proper.

(5) *On the highways of the World*: Another relieving feature of Sind - itself being unstable - is its position in relation to the civilised parts of Asia and Europe. It has been a precious link in the Afrasian belt of civilisation. It is on the high trade routes (including air routes): a stepping stone to the Far and Near East. It is indeed a most desirable connecting link with its neighbours. Hence its annexation required by the British towards the middle of the last century and its separation from the Bombay Presidency demanded by the majority of its people. Had it passed earlier into the hands of the East India Company and had its river some good outlets into the Arabian sea, this province would have been used as a more likely base for British operations in the sub-continent from the very beginning.

CHAPTER II

PHYSIOGRAPHY & GEOLOGY

THE REGION AS A WHOLE

Boundaries: The region, mainly characterised by the growth of the Indus delta, occupies the lower valley of the river. It covers 52,994 sq. miles including Khairpur State. It is bounded on the west by the Kirthar Range (misnamed Hala), along with a chain of minor hill ranges as far as Cape Monze, and on the east delimited by the Rajputana Desert. The Arabian Sea forms its southern boundary, while to the north it extends to the foot of the Suleiman Range and the extreme apex of the delta - a narrow neck of the Indus Valley, between the mountains on the right and the sand-hills on the left.

Two of these boundaries - the northern and the eastern - are only political and not physiographic, the former touching Bahawalpur State, forming part of Pakistan, while the latter is an international boundary with the Indian Union.

Distinguishing Features: The following are the outstanding features of the Lower Indus Basin :-

(1) The Indus river in this region does not receive waters from any large tributary as in its upper valley but, on the contrary, sends out distributaries into the Arabian Sea in the south.

(2) The area includes the old valley of the Indus, having reached its base-level of erosion, and aggradation is more or less complete. It is in continuation of the Khadar alluvium of the river in the upper region.

(3) The rocks within the region are mainly Tertiary, thrown

into anti-clinal folds, which are being continually eroded by sub-aerial agencies.

(4) There is an extraordinarily large number of thermal springs, some of which show a temperature as high as 126° F. and evolve sulphuretted hydrogen gas. Although there are some extinct mud-volcanoes noticeable in Makran and Baluchistan, no eruption has taken place in the region within recent times.

(5) The vagaries of the Indus River and its tributaries in the upper region of the Punjab have also affected this area to a considerable extent. Due to these hydrographical changes, as also to the fact that a whole river, called the Hakra, has dried up, a large portion of the alluvial plain has been converted into a desert, entrenched with old river beds, which remain dry during the greater part of the year, due to scanty precipitation in Sind. Drought and famine have been frequent in certain parts as there is a great scarcity of water-supply, both surface and underground.

(6) Climatically, the region is said to be "between the two monsoons" - the S.W. from the Indian Ocean and the N.E. or "retreating" monsoon, deflected towards it by the Himalayan mountains - and escapes the influence of both. The average annual rainfall of Sind is only 6 inches.

(7) But what is lost by the region during the two seasons is, however, regained for it by the Indus, the main artery of Sind, in the form of inundations, caused twice a year, by the spring and summer melting of the snows on the Himalayan heights and by rainfall during the monsoon season. Variations of diurnal and seasonal temperatures are also great.

(8) The growing and advancing delta is a characteristic feature, a large part of the existing deltaic lands being reclaimed during historic times. Small and large towns, which once stood on the numerous successive mouths of the Indus in highly pros-

perous olden times, are now completely thrown inland in a barren state and replaced by the present rock-bounded harbour of Karachi.

(9) Although there are no good mineral resources in the province of Sind, its chief asset is its rich alluvial soil, which requires little tillage or manuring, for yielding crops of grain as well as fodder throughout the year.

(10) Parts of the sandy desert are, however, overspread with natron-producing lakes called Dhands, which are characteristic of the Thar Desert. Salt and sand are continuously blown in from the Rann of Cutch by the agency of wind, and there are rich deposits of common salt (NaCl) and other salts found buried under sand-hills.

(11) Rain in the Thar Parkar area is not altogether absent; on the contrary in years of cyclonic storms there is excessive precipitation. The result is that the so-called desert land is, for the time being, turned into grassland, giving rise here to life and migration of population in intermittent seasons.

(12) Earthquakes and cyclones are not unknown. The surrounding mountains, being young and highly folded, are still in unsettled equilibrium and so earthquakes are not uncommon. In fact, Sind lies within the Danger Zone of this part of the earth.

In 962 A.D. the Indus River deserted Aror and even towns like Bahmanabad were destroyed.

1819 - Extensive changes took place in the Rann of Cutch affecting Sind.

From 1845 to 1861 not less than 7 earthquake shocks were recorded.

15th. October, 1896 - Shahbandar to Khanjuand through Thar Parker were affected.

14th. January, 1903 - Thar Parkar and Shahjanbad Districts. Fissures in Badin and Moghulbin Taluka with eruption

of warm water and muds of 12 hours' duration. Geyser-like blow-holes were left, 15-20 feet in diameter and 8-10 feet deep.

May 1905 - Dead fish were washed up off Clifton. A layer 5-15 feet thick and several miles long.

Another natural catastrophe is found in Cyclones which occur at times, e.g.,

13th. May, 1902.

13th. June, 1902. Wind velocity estimated to be 100 miles per hour. Tide rose 7′-2″ on 16th June, 1902.

1903 Tidal wave - Shahbandar Taluka. A tidal wave rose near the town of Sindree, situated where a branch of the Indus joins the Rann, which was permanently submerged on the occasion. A number of small cones, six or eight feet in height, burst up from the ground and continued for many days to emit bubbles of air and mud from their summits.

In 1945 another tidal wave (nearly 10 feet high) struck the Sind coast just after the Makran earthquake with gas eruption in the Hingol valley and a couple of transitory mud-islands off the coast.

Origin and Nature of the Indus Basin: To understand the nature of this Indus basin, it is necessary to know its origin. Although the Indus has been considered to be an antecedent river, having existed long before the Himalayas came into being, the formation of the Indo-Gangetic depression is, without doubt connected with the upheaval of these mountain during the Tertiary epoch. Resting upon the three or four primitive nuclei or fragments of an ancient land-mass, the land of Asia embraced the folded mountain belt from Asia Minor to the East Indies, across Persia, Tibet and China and grew, in the end, into the largest continent in the world.

The conception of the crust of the earth floating on the molten magma underneath is assumed by many geologists. In the




SEA
BALUCHISTAN
HALA MTNS
KARACHI
INDUS GORGE
ARAVULLI MTNS
MUSCAT
BOMBAY
MOUNTAINS 10,000 FT. HIGH
15,000 FT.
GONDWANALAND
LACCADIVES
REPRODUCED FROM THE DRAWING BY D. MACPHERSON PUBLISHED IN THE ILLUSTRATED LONDON NEWS

gigantic process of building the continents by means of the drifting and fusing of ancient land-masses with the mountain chains, there are local depressions and isolations noticeable. Discussing the structure of the whole continent of Asia, Prof. J. W. Gregory asserts: "During the process of deformation of the earth, the great mass of Africa acted as the hinterland or backland, which pressing northward against Southern Europe, crumpled it against the Northern fore-lands and that in Asia the direction was reversed, because the great mass which acted there as the driving hinterland, lay to the North and the great depression in the crust lay to the South. Accordingly, the dominant Asiatic movement was from north to south. We now know from the work of Mushketov, Klebelsberg, Wadia and others that the Asiatic direction was locally reversed opposite the mass of the Suleiman mountains and the Pamir, which acted as a hinterland between the two forelands of Arabia and the Indian Peninsula."

It is perhaps due to these opposing stresses working in the neighbourhood of our region that a trough came into being, and it grew deeper and deeper on the western flanks of the Himalayas, as they rose higher and higher and ultimately lay parallel with the range.

Similar events were happening in Africa and other parts of the world at the same time. The great meridional belt of ruptures which made the great Rift Valley of the Jordan, the Red Sea and the Nile basin, was due to the stresses between the Northward movements to the west of it and the Southward movements to the east of it.

The Indo-Gangetic depression was supposed by some scientists to be "a trough-fault similar to the Great Rift Valley of Africa and probably co-eval with the breaking up of Gondwanaland".

From a number of geodetic observations of the amount of deflections of the plumb-line at and near the foot of the Himalayas at different distances, viz., Kurseong, Siliguri, Jalpaiguri

(25 miles), Col. Sir S. G. Burrard, a former Surveyor-General of India, concluded that there was a rapid decrease in the deflections as one passed from the mountains to the plains, the reason being that "the attraction of the Himalayas was being counterbalanced by an attraction in the opposite direction and that an invisible chain of excessive density parallel with the Himalayas is underlying the plains of Northern India. Even the location of these hidden chain of rocks was suggested by Burrard to be some 150 miles distant from the foot of the mountains. Thus he deduced the theory that the Indus plain must be at first a "Sunken crack or fissure on its two sides".

But geologists, such as Fisher, Suess and Oldham have not supported Burrard's hypothesis and suggested that the Indo-Gangetic depression is "a foredeep between the wave front of the Himalayan system of folding and the horst of Gondwanaland produced by the elevation of the mountain range with concomitant sinking, partly due to subsequent overspreading of the submontane tracts".

The present view now generally accepted is that the Indo-Gangetic depression is "a broad basin, shallow on the outer side and sloping gently inwards towards the Himalaya, from which it is separated by a steep wall resulting from the series of reversed faults which separate the older geological systems from the younger".

Geological History of the Region: During the greater part of the vast cycle of geological time, Sind lay submerged under the Tethys Sea. Its land history is, therefore, comparatively brief - and yet the history as written by nature on its rocks is fascinating. For its birth, it has mainly depended upon the upheaval of the extra-Peninsular mountains, the Himalayas. How these stupendous mountains rose out of the ancient sea, and how they brought into being the two flanks, the Burmese Yomas in the east and the Suleiman-Kirthar mountains in the west, is a marvellous story. Incidentally the Indo-Gangetic basin came

into being, as stated above.

Even before this stage of the Himalayan upheaval, the earth movements - which took place in Peninsular India during the Cretaceous age, caused a bulge in the surface of Sind and there came on this surface the Cretaceous rocks in the Laki Range, the most ancient geological formation yet met with in this province. This was Sind's first appearance on the earth about 60 million years ago.

This exposure of the Cretaceous rocks in the Laki Range is due to a strike fault running throughout its length, caused by the stress of folding from west to east with an upthrown ledge on the west. The Hippuritic limestone (equivalent probably to the Turonian) at the base of the Barrah Hill, about 10 miles S.W. of Amri, is therefore, the oldest rock exposed in Sind. It is about this time that there was also the deposition of the Cardita beaumonti beds and the dark sandstones in the Cretaceous sea.

Then there was the memorable volcanic (fissure) eruption of the Deccan trap lavas in the Peninsula and Sind had a small share of it in the form of a 40-90 feet thick bed of basaltic trap, on top of the Cretaceous rocks in parts of the Laki Range.

The land, thus formed like an island in the Tethys Sea, remained dry for a long time after the lava eruption, during which period there were laid over it quite extensive deposits of Ranikot beds by the streams which flowed in the region. Coincident with an upheaval in the Himalayan region the dry conditions persisted till the sea overspread the region again, and there were formed more Ranikot beds containing coloured clays and some lignite, probably buried in a swamp or bay not far from the coast.

The land was again largely submerged in the Kirthar (Eocene) sea, which lay between the Aravallies and the western

mountains, and large deposits of limestone with soft and shaly beds were laid down. These compressions caused an upheaval and folded the rocks into anticlines and synclines.

Another continental period followed and there were temporary land conditions, now noticeable in the various ferruginous beds, commonly known in Sind as the Nari beds, formed by the influence of rivers in a shallow sea and in valleys between the Kirthar limestone bridges.

One more subsidence in the Miocene (Gaj) age gave birth to the well-known Gaj fossiliferous limestone, so well distributed in the Kohistan area and largely used as building material. These also contain fossil corals, enhinoderms and molluscs.

The last phase was fluviatile, marked by the Manchar formation of the Siwalik age. This was the age of mammals.

The Sind gulf was then replaced by valley streams, which completed the work of filling in many a bay and lake, till ultimately the sea was completely withdrawn, leaving the central valley for the Indus River to flow into, so that by the middle of the Pleistocene period the outlines of the geography of Sind had come into being. It only remained for the Indus to bring its alluvium and drop it into the valley with the detritus from the Himalayan heights. This gave a finishing touch to its physical features and shaped its topography. As the Indus delta went on growing southwards, and the level of the Indus plain was reduced gradually, the river changed its course now and then, swinging from east to west and west to east. Even to-day the process of lateral compression and mountain formation in the western highlands is not quite completed, the channel and mouths of the main artery of the land are not settled.

PHYSIOGRAPHICAL DIVISIONS OF SIND INTO PROVINCES AND SECTIONS

The area can be divided into two main divisions of land-forms viz., 1. Extra-Peninsular Mountains, consisting of some

of the high ranges of their western flanks lying between the Baluchistan plateau on the one side and the lower Indus valley, and 2. the Indo-Gangetic plain consisting of the aggraded valleys, the delta-land and the sandy desert tract. These parts are subdivided into smaller physiographic units as under:—

Main Division	Province	Section
1. Extra-Peninsular Mountain	I. Western Highlands	(A) Kirthar Mountains (B) Sind Kohistan Section.
2. Indo-Gangetic Plain	II. Lower Indus Valley	(A) Western Valley Section (B) Eastern Valley Section (C) Deltaic Area
	III. Desert Province	(A) The Pat (B) The Thar.

Method of Division: The method employed is that adopted by the Association of American Geographers for the physiographic divisions of the United States of America, which are very fruitful. In preparing the map of the Lower Indus Basin its Physiographic history has been considered, viz., the original structure of the land-forms, the process of land erosion by subaerial agencies destroying this structure and the recent stage of erosion or deposition of material thus eroded. The outstanding characteristics of the divisions depend upon these geomorphological factors and the value of each unit is based on its homogeneity. That is to say, each of the sub-divisions has a certain homogeneous physical background, which would be useful and suitable for considering its development from many points of view.

Need of Physiographic Divisions: The boundaries of these units which are elastic, are fixed with regard to their utility from the points of view of water-supply, economic resources, including agricultural products, industrial possibilities, population

problems etc.

Sections Distinguished:

Province (I) - (A): This consists of folded strata, containing hard and soft rocks of sedimentary origin, severely jointed, deeply ravined and fissured here and there. There is little soil and no vegetation, due to the scanty rainfall, in spite of the altitude reached viz., over 6,000 feet.

(*B*): These are lower ranges composed of monoclinal folds with undulatory plains in between. There is considerable subaerial denudation because of more rainfall here than in the Kirthar Mountain area, nearness to the sea and humidity of the air. The soil is cultivable in the valleys and supports more vegetation in them than on the ranges. One of the hill-ranges, viz., the Laki, contains some pre-Tertiary rocks and there is also a large number of thermal springs located chiefly between the latitudes 24° N and 26° N.

Province (II)- (A), (B) and (C) : These include valley-plains, chiefly overlain with alluvium, both old and new, trenched with river-channels in some places and overridden by raised beds in others. A few isolated, low limestone hills are the only relieving feature in the plains which are otherwise quite level. The soil is rich in salts and in minerals, derived from the silt and debris, borne down by the river from the mountain heights.

The Western Valley Section (*A*) is distinguished from (*B*) the Eastern Valley Section, by the presence in it of (i) old alluvium and (ii) seasonal springs flowing down from the Kirthar Mountain into the Western Nara and the Manchar Lake. Wind-blown sand and hydrographical changes are also characteristic of Section *B*.

(*C*) Deltaic Area - Largely uncultivable land consisting of mangrove swamps, *burkhans*, mud banks, shoals, sand-bars and flood plain. The chief characteristic of the region is the changing outlets of the Indus, which act as the inlets of the sea.

Province (III) - The Desert Province: This is a "regular sea of sands", of aggraded desert plains overlain with sand-hills. It is subdivided into (*A*) The Pat. This is the northern section of the desert consisting of clay or silt covered with longitudinal *bhits* or sand-hills connected by transverse ridges. There are also numerous *Dhands* or salt lakes.

(B) *The Thar :* This section is full of high sand-hills with a definite N.E.S.W. orientation, though the rainfall in this area is somewhat greater.

The whole of this Desert Province is distinct from the extra-Peninsula, the Peninsula, or the Indus plain Provinces. But it possesses the characteristics of all the three, having rocks belonging to the extra-Peninsula, while their structure is that of the Peninsula and the stage of erosion is that of the Plain.

PROVINCE (I): WESTERN HIGHLANDS

Correlation: This Province of the Western Highlands really forms part of the chains of extra-Peninsular mountains including the Suleiman and Hala ranges, and is capable of extension towards the north as well as the west. Its limits on these two sides are left undefined, until the work of designating the physiographic divisions of the surrounding lands and tracing their boundaries is completed.

Peculiarities of the Rocks: The Tertiary rocks of Sind, are in general similar to the Tertiaries of Burma, Assam and other parts of India.

(A) *The Kirthar Mountains*: General and Structural Features - The Kirthar mountains have a high relief, (4,000 to 5,000 feet above the sea-level) with transverse torrents running down the western flank into the Indus Valley. They are deeply ravined and fissured and mainly consist of folded strata, weak as well as strong.

They run north and south like a crescent turned towards the low lands and extend from the northwestern extremity of Sind

southeastwards to a little below the latitude 26° N. The maximum height is 6,877 feet above sea-level at Kutte-ji-Kabar (Dog's tomb); the southern end does not exceed 3,500 feet. It has a simple mountain structure of the regular anticlinal type, with the arches steepest towards the north and the west and gently dipping towards the south and the valley of the Indus.

The rocks exposed on the western flanks of the Range are Nummulitic limestones of the Kirthar (Eocene) series, while shales and soft sandstones are found between the ridges.

The whole range presents an arched or dome-shaped whale-back appearance, while its geology is singularly simple: "Many of the chains are perfect geological diagrams and from the absence of vegetation and clearness of the atmosphere, the outcrops of formations, such as the Nummulitic and Miocene limestones, may frequently be traced for many miles on the hill sides with absolute certainty from a distance".

Possibilities of hill-stations: There are two table-lands suitable for hill-stations on the Ridge, viz., (1) Dhar Yaro plateau, 6,000 feet high and exposed to high winds and having nearly a thousand acres of cultivable land. It has a mean summer temperature of 81° F. only and a rainfall of about 6 inches. Its ground is cut by water courses running down to the east into a deep and long ravine. The soil is yellowish red marl, washed from the heights, while the rock is red sand-stone interbedded with Nummulitic limestone. The well-known Kutte-ji-Kabar (Dog's tomb) is a junction of the eastern spur of Dhar Yaro with the main range of the Kirthar. It has other hills 3,000 to 700 feet high on its borders, so that the plateau is protected from all sides. (2) Danna Towers, a plateau 4,500 feet high, situated on the second middle ridge, 50 miles S.W. of Mehar. The ascent is irregular and steep.

The southern Kirthars run in the N. W. W. and S. S. E. direction with a gentle slope into Sind Kohistan.

Passage and Drainage: There are transverse lines of drainage

in the Range, which serve the double purpose of pathways through the frontier from the valley to the Iran plateau, e.g., the Mula, Mushkot and Bolan passes and of flood torrents down the slopes called *nais*, depositing a large quantity of boulders, pebbles, etc., along the hill-slopes. There are, also, a number of minor notches in the mountain, such as, Gazi Luk, Bakhar, Pinri, Harbab, Kamalune, Shakloina, Zamin, Phusi, Peei, Rohel Garre, Musefiri, Kutta and Daimang.

Nais: Among the important mountain streams issuing from the ridges and falling into the Indus plain are: (1) the Gaj *nai*, flowing through the Kamalune Pass and (2) the Nari *nai* joining the former at a later stage. Other hill-torrents, which are either lost in the sandy plain below or, being temporarily lost, flow through the Western Nara into the Manchar Lake every flood season, are the Sain, Kenji, Mogio, Trappen, Sita, Mazarani, Sahar Radha, Burri, Sulari, Khurbi and Maki *nais*. Some of these *Nais* are so powerful during the season (June to August) that they destroy fields and villages several miles away.

Near these streams, the hills are surfaced with gravel, while along their foot are heavier boulders, pebbles, etc. "These extensive gravel slopes are quite characteristic of climates like that of Sind with a low rainfall, because in such tracts, rock detritus accumulates along the bases of hills more quickly than it can be carried away by the streams. The rainfall is sufficient to wash down the disintegrated fragments from the steeper slopes but not to carry them forward where the fall is more gradual."

Valley forms: As the mountains are of recent origin and as the nature of rocks varies, different types of valley are produced. "There is here ample evidence of local disturbances in the alterations of levels, extensive valley plains occupying rock-bound basins and compressions of rock masses". Where the rocks are hard limestones, there are narrow and fissured like gorges, steep V-shaped valley sides, and rapid streams. But wherever they

are soft, e. g., shales or sandstones, the valleys are "broad, open, smooth below and filled up with stream deposits or gullies".

Instability of the land: These mountains of comparatively recent growth are yet unsettled and the region falls within the seismic zone of the earth. Now and again, there are tremors and quakes, as results of fractures, fissures or subsidence of rocks. This instability may also be due to the growing delta of the Indus and the fault lines recently discovered under Sind Kohistan Section.

(B) *Sind Kohistan Section* :

Delimitation: This section covers all the lower ridges of hills and the undulating plains of rapidly weathering rocks, east and southeast of the Kirthar Mountain, and extending as far as the sea coast in the south. The Indus bed lies flat against the higher levels of its right bank and cannot make any further advance against them. The hills constituting the ridges are named after some prominent peak or pass. There is an abundance of hot water springs and also a concentration of some metallic and non-metallic ores and minerals especially in the Jhangshahi - Jhimper region of Eocene rocks.

Topography: Low, parallel or sub-parallel ridges with broad undulating plains between them are the prominent features, indicating a lateral compression of the rocks acting west and east. The topography of this section is determined by the folded sedimentary rocks of the Tertiary system, disturbed by a vertical dislocation in the Laki Range and modified by the denudation by subaerial agencies to a great extent. The marine limestone, covered by soft clays and conglomerates yield to the action of wind and rain resulting in the characteristic undulating plains topography. There are a number of lateral ridges, hundreds of feet in height, pushing into the plains and becoming conspicuous by means of their numerous spurs and peaks lying in the midst of deep and wide valleys.

Chief Ranges (1) Laki Range - It extends north-south from Bhagothoro to Thano Bula Khan (height 2,202 feet).

(2) The Kambhu - 15 miles long, in continuation of the Kirthar mountain but only 2,340 feet high.

(3) The Badhra - Nearly 30 miles long, north to south a simple anticlinal roll of Nummulitic limestone with its axis continuing southwest and joining the Kirthar Mountain in the south by a cross ridge (height 2,436 feet).

(4) The Bhit - 20 miles long and 2,790 feet high. West of Badhra; it is almost flat-topped, "a great anticlinal saddle of Kirthar limestone".

(5) The Bidur - The eastern water-shed of the Habb.

(6) The Dunbar - 15 miles long and 2,200 feet high, lies between the Bidur and the Kirthar Range.

Structure of the Hills Ranges - Generally speaking, the anticlinals are steeper on the eastern side, and they "frequently consist of a double anticlinal fold with a small synclinal between. Faults and dislocations are of rare occurrence and those which occur are frequently parallel to the axes of the hill ranges."

Importance of the Laki Range and its History - This is the most interesting of all the Kohistan hill ranges. The Vira plain lies to the east of it, while a broad intervening valley opens out the road from Karachi to Sehvan. It is a steep anticlinal fold, faulted across with its upthrow towards the west and with prominent escarpments. A considerable number of the upper and lower Tertiary rocks are exposed in it, thus becoming a regular "Museum of field geology". It is the only locality in Sind where there are Cretaceous rocks exposed. A fissure eruption, contemporaneous with the lava flows of the Deccan, has left its mark in a bed of basalt 40 to 90 feet thick but now highly decomposed. Between this volcanic rock and the Ranikot beds there is a break, there being a layer of fluviatile deposits of variegated shales and sandstones especially in

the lower beds. The presence of oyster beds in certain places indicate local marine incursions in later geological times. Actually within the Ranikot beds there are layers of lignite, apparently showing marks of swampy area, into which the vegetation grew and was subsequently buried. Nearby, there is a layer of ironstone and ferruginous limestone and also laterite. As the Eocene sea receded at one time and attacked the land afterwards, the Nummulitic limestones were gradually deposited. Once again on the land becoming dry, the river and rocks of ironstone, soft brown sandstones, etc., of the Nari group were formed. Miocene times again saw the marine incursions for a while, until at last there was the dawn of the Siwalik age with its mammalian fauna.

Other Features: The whole range, though simple in structure, is much folded and is itself composed of several parallel ridges with valleys of varying breadths lying between them.

East of the range, there are only a few broken hills lying in gentle slope reaching the meanders of the Indus. There are a few passes, or notches, in it, viz., Girran, Hoshian, Hala and Gagar. Thano Bula Khan, about 700 feet high would make a good sanatorium.

All the newer rocks belonging to the Nari, Gaj and Manchar series, viz., sandstones, conglomerates, etc., being soft, lie denuded in valleys and plains, while the outcrops of compact and hard Miocene limestones do not suffer from extensive weathering and are conspicuous in many a detached hill in the south and southwest.

Mol and Myher Plateaus: The undulatory character of the Kohistan area is absent in two masses of rock, called (1) the Mol plateau and (2) the Myher plateau, both lying in the northwest of Kohistan and to the east of the Habb river. They are chiefly composed of soft Manchar rocks, which form a gentle synclinal or almost horizontal table-land.

Elsewhere the plateaux break up into the Gaj, anticlinals again predominating, as in the hills at Mangho Pir, Cape Monze, etc., in the north and northwest of Karachi.

Soil: The soils in this section derived from the native rocks are mainly residual, except in the valleys of hill-torrents in which some drift soil is found. They are calcareous and arenaceous and are thinly spread over the rock formations of the tertiary age. The texture is rather coarse with 50% of sand and the fertility is poor except in the ingredient of potash. The alluvium in the narrow valleys is, however, good and suitable for cultivation of hardy crops such as wheat and barley.

Drainage: (1) The Hab River. This is only perennial stream in the region. Its headwaters are in the Pabb range beyond the limits of our rigion, but its main stream forms a rough continuation of the axes of the Kirthar Range and the western boundary of Sind. An old but dilapidated *bund*, called Murad Khan's Bund, lies across it.

(2) The Baran. The Baran is next in importance, rising near Tako Baran in the Kirthar Range. It traverses the valley west of the Laki Range, where it receives the waters of the *nais*, and later cutting through it runs eastwards right through Kohistan into the Indus River, a few miles from Bolari Railway Station.

(3) The Malir. This is a seasonal stream, it joins the Khadeji at a later stage but remains dry for the greater part of the year. After heavy rainfall only, it flows in to the Gizri creek near Karachi. There is, however, an immense quantity of subterranean water underneath the sandy bed of the Malir, which allows of a number of wells and galleries along its right bank the only water-supply of this locality. Some distance from the Dumlotte gorge upstream, there is the confluence of the Malir with the Khadeji, this has a more or less perennial flow of water and also a small waterfall.

Among minor streams of a similar nature are: the Lyari flowing into the Keamari harbour; the Mohan or Rani rising from east of the Laki Range; the Sann; the Chorlo; the Nie Naegh and the Angyi; they all flow into the Indus or the Arabian Sea, if they are not lost in the sandy tracts along their course.

Thermal Springs: No faults have been traced in these localities but it is obvious that water percolating through the folded and fissured strata of the anticlines penetrates to a depth of thousands of feet and is heated in the interior. Release of pressure and the original head bring the hot water, charged with sulphurous gases, to the surface again in the form of hot springs. The most important are shown on the map.

The Mangho Pir spring is the hottest in Sind, its usual temperature being 126°F., it discharges about 180,000 gallons a day. Other springs have temperatures ranging from 80°F to 120°F.

Sources of water: That there is an abundant supply of water from the surface as well as deep-seated springs even at points hundreds of feet above sea level, has been proved at Dumlotte and other places in the Kohistan region; the natural dips of rocks are also favourable, e.g., towards the Malir valley. "Many of these (springs) are used up in irrigation, and a still greater number after flowing from one to ten miles disappear in the sand or flow off into cavities of the limestone formation, through which they pass to appear again doubtless in places at a lower level when faults bring the water to the surface." There are good chances of artesian wells in the Malir valley, this has been proved by a trial boring, 800 ft. deep, at the confluence of the Bazar and the Malir.

PROVINCE (II): LOWER INDUS VALLEY

The Province as a Whole: This valley presents a typical example of aggradation by the Indus throughout post-Tertiary times. On either side of the river, there are long stretches of

land, 2 to 12 miles wide, which are well watered, richly silted and cultivable.

This province is the most precious part of Sind and produces its main agricultural wealth. For this reason study of it is desirable from the points of view of :-

(1) Ground contours,

(2) Subsoil water-level contours (hydro-isobaths),

(3) Soil indications.

(1) Ground Contours : The accompanying map of ground contours shows that the fall of the country is only about 180 feet, (from 200 feet contour in the northwest to 20 feet in the south-east corner) for a distance of about 250 miles i. e., nearly $8\frac{3}{4}$ inches per mile only.

The contours in the northern tracts run almost N. W. S. E., those in the middle nearly E. W. and across the river bed, while those in the south almost N. E. S. W.

It is easy to understand that the bed of the Indus itself is higher in level than the surrounding country.

The map shows breaks in the contours of areas too high for the Barrage to command.

There are practically no rocky outcrops or eminences in this valley.

Such a plain is ideal for cutting canals in any direction.

(2) Subsoil Water-level Contours : Two maps showing the hydro-isobaths of the two main season, October (after the rains) and April (before the rains) have been prepared. It is a characteristic of the province that the subsoil water-level rises at the time of every inundation. On the right bank especially, a high subsoil water-table exists, varying from 3 feet to 13 feet below the surface. On the left bank conditions are slightly better.

Under the old inundation canal system, because the inundation ceased to flow between the end of September and the

beginning of October, the subsoil water-level had time (nearly 8 months), to recover before the next season; now, however, under the perennial system of the Sukkur Barrage the drainage capacity of the soil has been greatly affected, and there is "a persistent upward trend in subsoil water-level" following the general principle that the flow of water through subsoil is from areas in which the level is high to areas in which it is low. The average annual rise is 9 feet. As the whole area is sufficiently saturated by irrigation water, the effect of additional rain-water during the season has little effect on the subsoil water-table.

October readings. These show that the water-level contour below the surface varies from 4 to 8 feet near the bed of the river to about 12 feet near the frontier on the right bank; while the level is considerably below the surface even in the neighbourhood of the river banks on the left side, viz., 16 to 24 feet. In Khairpur State, the level is very high, viz., only 4 to 8 feet, a result of the passage of the large Rohri canal.

April readings. Contours on the right bank vary from 8 to 12 feet near the river bed to nearly 24 feet towards the N. W. frontier. On the left bank the levels vary from 12 to 16 feet near the Eastern Nara Valley. In Khairpur State it goes down to 8 to 12 feet only.

By comparing the April and October hydro-isobaths maps we find that although there is an average drop of about 4 feet in April, the water-table is generally only about 8 feet below ground level. This is the situation on the left bank, while in Khairpur State and in some parts to the south there is a general tendency for the subsoil water to rise after the rains in October.

Within the Barrage area, observations of the Sind engineers have shown that the rise of water-table has been one feet in 10 years.

Outside the Barrage area the depth of the water-table varies from 60 feet in the Kohistan region to 300 feet in the Desert region.

Utility of these Maps: The above information is a guide to the solution of the problem of seepage and water-logging in Sind. Contour plans of subsoil water have been prepared by the Development and Research Division since 1930 for the month of (1) April when the level is lowest before the Khariff season begins; (2) October when the effect of monsoon irrigation on the land is clearly marked. Formerly, observations were made twice a year of the rise and fall of the water-level in existing wells in some parts of Sind. The more systematic readings, obtained in recent years, by the Public Works Department, have enabled them to track rises and falls of the subsoil water-table and to suggest plans for the prevention of water-logging in certain localities. It has been noticed that the area suffering from water-logging in Sind is confined only to the neighbourhood of canals and results from seepage through sand-beds and banks; it is very small compared with the whole area commanded by the Barrage and this form of seepage is annually reduced as the sides of the canals are gradually, but unevenly, sealed by silt deposits. These deposits have however been found to be fewer on the left bank area than on the right.

It is believed that seepage and water-logging below the Lloyd Barrage are caused by a buried ridge or up warp extending from Kohistan through Sukkur to the Suleiman mountains and this is indicated by gravity data which were obtained by the Survey of India (Vide Geodetic Report Vol. VIII Chart 9). It is possibly an obstacle to the Sub-soil flow of water, and is thus causing a rise in the table.

(3) Soil Indications: In a province, dominated by a powerful aggrading river like the Indus, the soil is largely alluvial and sand is likely to predominate over silt or clay. The results obtained by the Research Division, however, show that the nature of the surface varies considerably from place to place and that there are layers of sand belts (containing sand and sandy silt) and clay belts (containing clay and dry silt) spread through-

out the province. These belts are of various thickness, up to 12 feet, coarse sand underlies the whole area to a depth of 70 feet, and the depth of soil itself is found in several boreholes to vary from 30 to 200 feet and more. These layers are impregnated with salt and abound in calcareous shells of animals.

On the whole, the sand belts are wider in extent than the heavy soil belts on both sides of the river valley and they run nearly parallel to one another, enclosing within them the deposits of clay.

On the right bank, the main sand belt spreads continuously under the area, while in the left bank area these sand belts are not continuous but broken and stretch for long distances from north to south, showing clearly the vagaries of the river and its various branches from time to time. Nearer the Eastern Nara and towards the south clay belts predominate, showing that this stream, unlike the Indus river, deposited silt through its flood waters but did not leave its bed and later cut through the clay belts.

These sand and clay belts probably indicate that the whole of the valley originally consisted of silt and clay, deposited by flood waters from the Indus, which were pounded against the Kirthar Hills on one side and the sand-hills on the other and in a still condition and that "after the formation of this large expanse of clayey material, the river meandered through it cutting away the clay on its course and leaving sand in its place thus accounting for the sand-belts which exist at present".

Commenting upon the result of the investigations, Mr. Hawes says that a survey of the soil strata before the construction of any canals would have been highly advantageous; to have aligned them along clay belts, which are impervious, would have done much to prevent seepage and water-logging. Here and there are also patches of Kalar (salt) bands.

Special Drainage Features: One important feature of the

drainage of this portion of the province is that it is confined to a comparatively narrow tract, therefore large and permanent marshes exist on both sides of the Indus as a result of flood waters: (1) The Western Nara tract including the Manchar Lake gives rise to forests near Shikarpur and Larkana; (2) the depression from Khairpur to Umarkot now occupied by the Eastern Nara channel.

In the immediate neighbourhood of the river itself the ground is rather higher, because silt deposits are considerable and these are covered up by wind-blown sand.

(A) Western Valley Section:

Boundaries: This section chiefly comprising an old alluvial plain lies in the N. W. corner of the province. It is bounded on the north by the outskirts of the Suleiman Mountain, while the barren hills of the Kirthar form its western boundary. In the south the section narrows down into Kohistan with the Manchar lake as a prominent boundary landmark. The line of the most westerly meanders of the Indus forms the natural eastern margin.

Special Features: The topographical feature of the section is an uneven alluvial valley plain with a few outcrops of Tertiary limestone. It forms a wedge-like portion of low land and between the Afghan Mountains and the Baluchistan Ranges and has a foundation of Tertiary strata, outcropping in a few anticlines. It is now nearly covered with old alluvium, which has mainly been deposited by the Indus waters. Although almost flat, the countary is not without gentle slopes here and there. Tabular uplands and well-marked Bhabar slopes of gravel are common between mountain streams. In other parts as a result of silt deposits a gently rolling character of Bhangar (aggraded river parts) in the form of mounds is developed. The mountain torrents are soon dissipated on reaching the plains, leaving gravel, and sand-dunes, small and large, to lie scattered here

and there. With the slighest obstruction from without or with any diminution of water within its body, the river deposits material in the flood plain. These deposits are more within the continually changing beds of the Indus than on the banks, and so they rise above ground like dykes. The slope of the plain is less than one foot per mile in places. This coupled with the fact that the Kirthar rocks near the flanks of the mountain dip down towards the interior, has caused a depression in the midland area. The Western Nara, the Manchar Lake and the Aral River lie within this broad and shallow belt of land, which is like a loop of the Indus River itself. This secondary waterway is also fed by other streams draining the mountain system of the Kirthar during the rainy season. There is plenty of fresh-water under ground, so that the Manchar lake, which absorbs the main drainage of the area, has come to be the biggest fresh-water lake in India.

Towards the Northern part desiccation is great. Although most of the land has been brought under cultivation by means of irrigation canals, there is a portion of desert land still left in the north-west corner. Owing to the small rainfall, the country between Jacobabad and the Bolan pass, thirty miles across, has remained a rainless desert destitute of any irrigation and is called the Pat. It chiefly consists of indurated light coloured clay, deposited by the Bolan and other mountain streams. The waters, charged with clay, are simply lost in the sands. Elsewhere, there are patches of salt and sand covering mounds now much eroded by casual floods. Wherever there is impervious clay covering the surface, *dhands* or salt lakes are formed. Of these are: Dhand Saro, Dhand Daba and Dhand Changro.

A slope of gravel brought down by hill torrents, similar to the Bhabar at the foot of the Himalayas, extends along the edge of the Kirthar Mountains forming a piedmont zone between the western mountains and the alluvium in the east.

Soils: The soil within the area is very fertile. It is rich

loamy alluvium, containing plastic clay, sand and salts. Old alluvium predominates in this section, and soil of the carbonate of saline and alkaline group is commonly found.

The silt, deposited by the river, is found to contain "particles of clay, slate, quartz sand, decayed vegetable matter, micaceous, talcose and chloride schists, gneisses, etc." These components are derived from the rocks of the mountainous region through which the drainage passes. From time to time seeds of grass are brought down by the waters.

Potash (K2°) and phosphoric acid (P2°5) are in good proportion in the valley and assure the fertility of the soil. They counter-balance deficiency in nitrogen. The proportion of clay increases to 22% in the alluvial tract. A crumb structure is found in loamy soil due to the grains aggregating, although it may be loose and friable. It is excellent for the cultivation of cereals and cash crops.

Drainage: (1) The Indus river is the very life of land. Its vagaries and instability, however, are proverbial. Its chief feature is the annual inundation period. Its aggrading character within the region of our study, has been responsible for most of the geomorphological changes which have taken place. This subject has been fully dealt with in the Second Chapter.

(2) The numerous *Nais* or mountain torrents, are occasional and not perennial but rising in the Kirthars they supply much surface and subsoil water to the region. Among them may be mentioned the following :—

(i) The Gaj *Nai*: This is the most important and longest, and discharges as much as 150,000 cusecs up to February each year. This *Nai* debouches into the Western Valley Section through a gorge and cuts it in two narrow channels, one originating in Halawar near Kalat and the other in the Kirthar. It has three exits in the northerly, southerly and easterly directions. Its floods are heavy and devastate large tracts of land.

(ii) The Mazar *Nai*: This is in the Warah Taluka and is provided with a bund, which holds its waters in the form of a 10,000 sq. yard lake, for irrigation purposes.

(iii) The Khenji *Nai*: It is situated between the Upper Sind Frontier and the Larkana District.

(iv) The Delan *Nai*: This is made up of three smaller *Nais* in the higher reaches and remains active for the greater part of year, supplying water to nearly 5,000 acres of land.

(v) The Nari *Nai*: This drains a large part of the hilly tract and is joined by the Letan *Nai*.

(vi) The Sita *Nai*, and (vii) The Salari *Nai*: are other minor water channels.

All these *Nais* flow ultimately into the Manchar lake.

(3) The Western Nara: From the nature of its level banks, its many meanders and the absence of mounds on its sides, one is inclined to consider this to be an old channel or at least a branch of the main river system, the Indus. It runs parallel to the mother stream for some distance. It was projected into a canal by Col. J.G. Fife, R.E., sometime Head of the Irrigation Department of Sind. This stream finally falls into the Manchar lake. It is navigable during the monsoon season, between May and September, and is preferred for this purpose to the Indus during this period. The Manchar Lake at the southern end can be regarded as a local expansion of the channel.

(4) The Gharo Stream: This is supposed to be a natural river of a similar kind, but it is deeper and wider than the Western Nara.

(5) The Aral: The most interesting of all water channels in Sind is the Aral. It is only 17 miles long and leaves the Manchar lake at its extreme southeast point, flowing eastward at first and then northeastwards, till it reaches Sehvan. Here it joins the Dunstar *wah*. After rounding a little, the combined

channel turns southwards, until it reaches the Indus near Bhagothoro Station. More water goes into the Manchar lake through this short water-course than through the long and worn-out stream of the Western Nara. It cuts the Indus almost at right angles. During the off-season, as the pressure of water decreases, the Aral flows backwards and reversing its action becomes a drainage channel from the Manchar lake into the Indus.

(6) The Manchar Lake: By far the most important of the numerous *Dhands* or lakes in the region is the Manchar lake. It is only 8 to 9 feet deep and is a mere alluvial depression. It is bounded on the south by the Kohistan high-ground and is fed by the Nara, the hill torrents and the Aral described above. As the level of the river bed is higher than that of the level of the lake during the season, the lake acquires a wide expanse, after an inundation, towards the north and the northeast, covering over 200 sq. miles - the largest fresh-water lake in the subcontinent. During the off-season it remains restricted to an area of about 14 sq. miles as a result of post-monsoon drying. This characteristic of a periodically changing level, filling and emptying alternately, gives the valley some 186 sq. miles of excellent land cultivable during the cold months. There is a scheme to drain the lake entirely in the cold season and thus provide, for Rabi cultivation, some 20,000 acres of arable land.

(B) Eastern Valley Section:

This section of comparatively recent alluvium, covered in parts with sand-hills and *Dhands*, extends along the left bank of the Indus from Khairpur State in the north to the delta proper and the Rann of Cutch in the south. It is bounded on the east by meanders of the Eastern Nara, beyond which is the extensive desert region of the Thar. Drainage is deficient in this section.

Topograpny: Almost the whole of the section is overlain with

recent alluvium, extending for many miles between the Indus and the East Nara. In the northern parts, the levels are higher, in some places more than 400 feet. As we go southwards, there is a gradual fall in level, until near the margin of the delta proper, the elevation is less than 50 feet. There is a similar gradient from the Indus river course eastwards towards the Nara river.

Large masses of land are covered with silt deposited by the river and sand blown in by the winds from the south and the southwest.

The entire surface is furrowed and cross-furrowed by beds of old river channels, which have left their fertile meanders in many places.

Relief: Apart from a few outcrops of limestone rising above ground level, the area is flat. In the northern extremity of the plain, it just touches a range of hills, running north and south and rising to a maximum height of 413 feet above sea-level. In the middle near Hyderabad and along the latitude 25°21' N., there is a similar flat-topped range of Tertiary hills 14 miles in length, but only 252 feet in height. These dip gently in an easterly direction and are scarped mostly towards the side of the river. Still further south, near Thatta, are the isolated outcrops of the Makli Hills. They are of the same geological (Eocene) age, the rocks dipping gently towards the west and southwest. These few outcrops of hard rock embedded in the alluvium consist mainly of Nummulitic limestone of the Kirthar series, interbedded with green clays and gypsum.

Some idea of the accumulation of fluviatile and aeolian deposits and the consequent elevation of the surface in this region can be obtained from the observations on the levels of the large hollows found between the sand-hills and filled with flood waters from the Eastern Nara. These levels, in places 300 feet high, must have been "at least as high as the general surface of

the Indus plain at no distant date".

Soil and Climate: The soil, mainly composed of recent alluvium, varies in composition from place to place and is rich enough to yield various kinds of crops. It is hard, sunbaked clay when devoid of water. A large part of the belt of land between the Indus and the Nara - the Doab, 70-80 miles wide - is very fertile, being covered with subaerial stream deposits. The types of soils found in the Western Valley Section, viz., *Wariasi*, *Kachi* and *Chiki* are also found in this portion of the basin.

The full vigour of the hot and rainless season is experienced in the north, and the line beyond which the S. W. monsoon rarely reaches, is the latitude of 25°20' N. The rainfall varies from year to year and place to place but the average is about six inches. On the whole the climate is dry and typical of Sind.

Drainage: The area lies between two water courses, viz., the Indus on the one side and the East Nara on the other, the quantity of water in the latter depending upon the floods in the former; and in a depression in Bhawalpur State further north. There are no mountain torrents or other perennial streams, as in the Western Valley Section.

The Eastern Nara is an old bed of an eroding river, which is lost. It runs almost parallel to the Indus showing the slope of the ground away from the main stream. Though it is called *Nara*, it is very wide and about 8 to 10 feet deep. Between the towns of Chundawah and Nawakot, the Nara, or, as it is locally called, the Hakra, skirts the Thar Desert. At Nawakot, the river flows in two channels, the larger one running in a southeasterly direction to Wang-jo-goth, where it joins the Puran, and the other continuing to skirt the Thar for about 30 miles, after which it joins the Puran below Wango Bazar. From here the waters of the Nara pass to Lakhpat by means of the channel to the Puran where, after completing a course of about 300

miles from its head, they enter the sea near the Koree Creek. "Numerous *dhands* occupy the valley amounting in the aggregate to nearly four hundred, some of them being as much as three miles in length by one in breadth." Enormous crocodiles live within the stream throughout the year.

It is well known that the Eastern Nara has lost its source of water because of the divergence of the Indus and other rivers, especially the Sutlej, in the Punjab. The result is that a large portion of what was once fertile and well-inhabited land lies barren to-day.

Among the other old water channels of the Indus river now converted into irrigation canals are the Fuleli, the Gujah, the Gungrome, the Pinjari and the Gunjree, all ultimately flowing into the numerous delta creeks in the south.

Dhoroes: But one remarkable feature of the drainage in this section is the numerous *dhoroes*, or dry water channels, found at short intervals. They are about 100-200 yards in width and from 2 to 10 miles long. They are without apparent continuation at either end, and seem to merge into the sand-hills in the neighbourhood. They remain dry throughout the year, and so their beds are cultivated by lift irrigation. How these channels were formed is doubtful, but from their nature they seem to have had some connection with the main drainage-system of the country in the past. Lower in the section, a few of these *dhoroes* are continuous and reach as far as the sea.

(C) *Deltaic Area:*

Limits of the Area: The deltaic area is limited by the coastal strip as far as Cape Monze to the northwest and by the numerous spurs of Kohistan. Thatta marks the apex, which is also the limit of the tide waters which ascend the river for about 60 miles. Towards the S.E., the delta extends as far as the Rann of Kutch. The shore line, scalloped with the numerous outlets of the river and about 125 miles long, forms the base of the triangle.

Outstanding Features: The deltaic area is of recent growth and is still growing. The *Khadar* (low-land plain) of the Indus imperceptibly merges into it. Unlike the Ganges delta, it is uncultivable, uninhabitable and unstable. Within its limits the *Khadar* alluvium cannot be distinguished from the *Bhangar*. On the other hand, the Ganges delta is not as well-defined as this one; it is of normal type and the river channel is bordered by high banks with grounds sloping away to swampy areas.

Changes in the Indus delta are caused by the changing character of the mouths of the river itself as well as by the stormy nature of the sea during the monsoon season. It is largely "furrowed by ancient river channels some continuous throughout the deltaic region and for many miles above it, but very many others in a more or less obliterated condition and traceable but for short distances". This is especially the case here, because towards the north of the delta, the surface is largely composed of loose micaceous sand, which facilitates the shifting of the water channels. These changes are believed to have taken place in the last 900 years.

At the time of the tide the coastal strip is submerged for 3 or 4 miles, so low and flat is its topography. When the river is at its greatest height in the monsoon, the delta is flooded to about 20 miles from the coast. Extensive mangrove swamps emerge in the creeks, when the tide waters are withdrawn. The whole area presents a strange conglomeration of mud banks, sand dunes or *burkhans*, and swamps or lagoons. These help in the process of altering the river-courses within the delta. Wherever old creeks have dried up, considerable masses of common salt have been left over and buried under the muds. Sand has covered the low rugged limestone hills of Thatta and Gurrah like a crust. Westward of the Gurrah Creek up to Karachi and Cape Monze, the shore is rocky but low and covered with sand.

History and Development of the Delta: A very large part of Sind can be taken as ancient delta country. From some of the old

maps of Sind we find that the delta has grown considerably even during historic times, and that the Indus has swung several miles on either side, except at certain fixed points in its course through the land; and that at one time it flowed due south into the Gulf of Cambay; that its flood waters flowed into the Eastern Nara; and that its mouths are changing both in number and and position. In the oldest map of Ptolemy there are shown seven branches flowing out into the Arabian Sea at points quite different from those found in later maps. The oldest head of this growing delta can be easily placed at Hyderabad. Later Thatta became the apex, and now, as it is considerably advanced, it has shifted several miles southwards. Towards the east, the delta receives little water from the Indus.

The history of the delta has been recorded in various mouths of the Indus, ancient and modern. The Koree mouth seems to be the oldest, it was the opening of the Eastern Nara or the Puran at one time and the Fuleli at another. Until the beginning of the 18th Century there were eleven mouths noticeable with the Baghiar and the Sita as its two navigable arms. The earthquake of 1819 produced some changes. The Koree Creek was considerably widened by subsidence. Shahbunder on the Begana or Mol - a prominent port - was closed down, the Bhagiar was deserted and Kukaiwari and Khedewari Creeks came into prominence about 1837. In 1867, Kukaiwari was blocked up with sand and the Hajamro, formerly known as the Sian, became the chief river port. Before Karachi and Kotri were opened for traffic by rail, the Piti and the Juna Creeks served all merchant ships and ships of war. Gizri was also a port till recently.

The growth of the delta is marked more towards the southwest. Many of the ports which stood on either side of the river in the past suffered on account of the shoals and sand banks thrown up near them by the sea, which during the monsoon season becomes heavy and tumultuous.

The mineral character of the muds near the Keamari harbour is the same as that of the Indus silt. These muds are drawn in by the S.W. monsoon current as a result of the oblique action of sea-waves.

Comparison with the Nile Delta : The growth of the Indus delta is not as rapid as that of the Nile, the reason being that the Mediterranean Sea is calmer than the Arabian Sea. The shore lines are being vigorously worn away by waves, which have a disastrous effect on the Indus delta. The discharge of solid matter in the case of the Indus is 217¼ million cubic yards per year, against 240 million cubic yards per year in that of the Nile.

Soil and Vegetation : Low and swampy shore lines overflowed by tides mark the outer boundary of the area. Above this line, sandhills predominate, and higher the soil is argillaceous, mixed with clay and sand, which hardens on exposure to the sun. It is impregnated with common salt.

In the marshy area, good pastures of tall grasses are available, while tamarisk and mangrove grow in the interior. There are a few fertile fresh-watered patches between the river branches and above the swampy plains, in which red rice is grown.

PROVINCE (III) : DESERT PROVINCE

Limits and General Description; This province forms a part of the Rajputana Desert. It is called the Thar-Parkar. It lies within the desert belt of the tropics, between latitudes 24° N. and 28° N. Its western limit is fixed along the course of the East Nara or Dhoro Puran, as far as latitude 26° N. From here it extends northeast along the edge of the sand-hills as far as Bahawalpur State. The eastern boundary of the region is only political, a large portion of the Rajputana Desert in the neighbourhood being of the same origin and category.

The province is distinct from the alluvial plain on its west, because it is on higher ground and almost wholly covered with sand and *Dhands.* It slopes slightly from east to west, but rises

from north to south. It is barren even when it lies within a few miles of the river.

Not a True Desert: This province cannot be called a typical desert, it is neither entirely barren, nor rainless. It is not completely uninhabitable. On the other hand, the presence of furrows of ancient river beds towards the north, with the ruins of towns and villages along them, and the course of the Nara River, shows that this region was far more prosperous in the past than it is to-day. Cattle, camels and sheep still live on its scanty water and vegetation. To some extent parts of this desert are gradually being brought under cultivation, so that there are now zones of gradation all around, principally in the Pat area.

Origin of the 'Desert' Province: The desert conditions are due to several circumstances:

(1) Considerable Sub-aerial Denudation: Whatever solid rocks existed within the area, they have suffered destruction through "the process of desquamation" producing characteristic topographical features "of sand blasted, treeless landscapes, one sees for miles around under a clear, cloudless sky".

The diurnal as well as seasonal variation of temperature is considerable and there is no organic or chemical agency to turn this debris into soil or humus.

(2) Aeolian Deposits: There are enormous deposits of wind-blown sand, transported from the shallow Rann of Kutch and the coastal area in the south of the Thar. Sand-drifting takes place on a gigantic scale during the S. W. monsoon season. Rounded grains of quartz, felspar, mica and hornblende found among sand, show the distintegrated parent igneous rocks from the Himalayas and the Aravallis, have been transported here in past ages. The presence of calcareous grains indicates the decomposition of sea shells on the coast lines.

(3) Vagaries of Rivers: The whole region, entrenched with old

river beds, suggests that in the past it must have been favoured with more water and better drainage.

(4) The presence of salts like chloride of sodium (common salt) in the soil, renders the land barren.

Soils: Blown sand in this subdivision raises the sand percentage to more than 60%, clay is least on the surface, while it has almost double the amount in Kohistan and three times in the valley. As the proportion of sand decreases, that of clay and silt increases. The lime-magnesia ratio sinks as low as 3:4 or 1:1 in the Thar tract, with the proportion of phosphoric acid, potash and lime also greatly reduced.

(A) The Pat Section: The force of the S.W. monsoon is not felt here so much as in the Thar Desert section described below. The longitudinal '*bhits*' or sand-hills are haphazard and transverse ridges lie across them. The hills are not as high as they are in the south, many are not over 300 feet, but they are large and generally N.S. On the whole, the area is less rugged, and flatter.

The soil is loose and sandy, presenting a dry and arid appearance and lies on fine clays and silts impervious to water. As a result of this, there is no leakage of water from the streams and canals running through the alluvium. Any rainwater, that falls into the hollows between the sand-hills, is held up and *Dhands* or lakes charged with *reh* or '*Kalar*' are formed.

Some parts of the Pat, especially in the Nawabshah, Sukkur and Khairpur State districts, have been brought under cultivation and the sand-hills more or less eliminated up to a contour line of 200 feet. Because these parts are higher than the main water channels irrigation is maintained by 'lift' and not by 'flow' method.

The greatest peculiarity of the Pat Section is that even with very little rainfall (average 3 inches) or flood waters, the hills are covered with a surprising amount of vegetation, shrubs, etc.,

upon which cattle live; the valleys are filled with rank grass or cultivation.

Dhands : Salt water or natron-producing *Dhands* are a characteristic of this region and are evidence of the former sea which communicated with the interior. The salt lakes are formed within deep hollows, between sand; they are elliptical, low lying and flat and oval-shaped basins, not deeper than 10 inches with their long axis parallel to the main '*bhits*' and therefore to the wind direction. They serve as 'huge flat-bottomed evaporating pans', and are without outlets. Both the '*bhits*' (ridges) and '*talis*' (valleys) are frequently covered with vegetation, as there is some rainfall (at times 5-10 inches) in the locality. Although much of the rainwater soon evaporates as a result of the heated sand mass, some percolates to the impervious soil below, and is held there for sometime or ejected in the form of salt springs *(Sim).*

The factors controlling the salinity and desiccation of the *Dhands* are (i) withdrawal of flood waters, (ii) approach of summer, (iii) blowing of loose sand, (iv) salt-charged soil.

It is another peculiarity of the *Dhands*, that after a huge inundation of the area they lose their individuality and are temporarily joined together. Later when the flood waters subside, they regain their individuality and aridity and increase in salinity.

There are many such *Dhands* in Sind. In Khairpur State alone there are some 129. The following are a few typical *Dhands*:

Haleji, Jhimpir, Dhore, Kinjhar and Sonahri.

The following analyses of the salts is typical of the salt-lakes in Sind:- Name of *Dhand*: Bagarwaro (Khairpur State) Co-18.48, C1-5.3, S0-19.3, Na C0-33.4, NaH C0-17.6, Na Cl -8.8, Na S0-28.6, Carbonate-biocarbonate Index.

Some of these salts are produced by the interaction of acids on the soils and sands of the locality.

(B) The Thar: This section is a wide expanse of several thousand miles entirely covered with sand except for some elevated parts. It consists of "a tract of sand-hills, resembling the waves of a troubled sea", generally higher in the west than in the east. There are salt encrustations generally about an inch deep.

The direction of the sand-hills, some of which exceed 500 feet in height, is parallel to the prevailing wind (i.e.), N.E.S.W. or E.N.E.-W.S.W. further up. Near Khipro, as the force of the wind currents diminishes northwards, the direction of the '*bhits*' or hills also changes to N.E. by S., and further northwards to N.N.E. S.S.W., until finally they strike N.S., as the zone of gradation is approached.

These longitudinal hills are mostly restricted to the coast and the western borders of the Thar, where the wind current is stronger locally. The '*bhits*' are not connected and lie in parallel ridges. Between them the original alluvial soil lies exposed.

Wherever the quantity of sand is great, there are formed plateaus (drain) of deep sand continually changing shape with the direction of the wind, until they grow into "a sea of sand with beautiful irregular curves of hills and hollows".

Paucity of Water: During the monsoon, the southern parts of the desert are flooded by sea-water and also by fresh-water from the channels swollen after rainfall. In the dry season and near the Nara, water is generally found at one to two fathoms from the surface; it is a little brackish, but because of its scarcity people drink it. "It is obtained by digging temporary wells, at the bottom of which a wooden foundation of the shape of a wheel is placed, and the sides are then built up with wicker work of green branches and brushwood, to prevent the soil falling in; the water thus filtering through the sand is sweet, so long as the wells are regularly worked."

As we go further inland the conditions change. "In the

interior the depth of the well varies corresponding to their distance from the Rann; where, of any considerable depth, they are built up with burnt bricks, stone not being procurable and wicker work too insecure; 30 miles 'inland the wells are 60 yards deep'. In Chhachhro, however, the water-table goes down to 300 feet and more. Surface water is rare in this region, although *Tarais* or tanks are constructed in some parts for collecting rain water.

Rock Exposures : From a few outcrops of Malani rhyolite, Cuddapah trap and crystalline complex in the Rajputana Desert one may expect a wide distribution of solid geology burried under sand in this section. "It is quite probable that a large extent of fossiliferous rocks, connecting these isolated inliers, is buried under the desert sands."

The only prominent outcrops within the arid district of Nagar Parkar that have escaped complete denudation or burial are those of the Kalanjhar (Kalingar) Hills rising to 1,169 feet above sea-level. These isolated hills differ materially from every other rock occurrence in Sind. They belong to the Dharwar and other pre-Cambrian systems and are, therefore, associated with the neighbouring Aravalli range, with syenite as the main rock-component. Evidently they form the extreme end of the once stupendous mountain system of Rajputana, which is now so greatly degraded and denuded.

The Parkar District : This part of the desert, situated in the southeast corner, differs from the rest in the matter of rainfall, which though variable, ranges from 4 inches in Sanghar to 15 inches in Nagar Parkar. While at one time there is practically no rain, (e.g. 4 cents at Khipro in 1899) at another time there is heavy and torrential rainfall, (e.g., 41 inches at Mithi in 1913). There are two perennial and some seasonal springs in the region and the soil is a medium sort, — a mixture of stiff clay and fine sand and is cultivable for good Rabi crops, e.g., Bajri and wheat. Another difference is that the sand-hills of the Thar are replaced by ranges of hills composed of the solid

rock mentioned above.

ECONOMIC RESOURCES OF THE LOWER INDUS BASIN

(I) Western Highlands:

(A) Kirthar Mountain: (1) Building stones of great durability are found in the Kirthar Range as well as in Kohistan, especially in the Ranikot bed, at Jhirak, which yield light, yellowish or brown and fine-grained limestone of an excellent character. The blocks are large, and the joints are far apart. Good ferruginous sand-stone of the Nari series is also available near Jungshahi.

(2) Alum is obtainable from pyritous shales found in the Gaj beds near some *Nais.* The manufacturing process consists in "a rude lixiviation of pyritous shales in the Gaj, Ranikot and Nari groups on the flanks of the mountains, the necessary potash required being obtained from the ashes of certain plants."

(3) Quicklime is prepared on a large scale from local limestone quarries in the mountains.

(B) Kohistan:

(1) Lignite: A layer of lignite, a brown coal, among the Ranikot beds (shales and sand stones) in the Laki Range has already been referred to. Two seams were found at Linyan, 27 miles N. N. W. of Kotri and 15 miles from the present course of the Indus. One of these proved to be lenticular but of good thickness.

Although, at the time, the coal deposits were found to be meagre, it seems that in recent years sufficient prospecting has not been done.

(2) Petroleum: There was an experimental boring for petroleum made at Sukkur in 1893-5 but it did not prove successful. An experimental well was dug by the Burmah Shell Co., near Khairpur Mirs in 1922-3, but the results are unknown. Oil indication was noticed at Drigh Road, a few miles from Karachi, but subsequent prospecting during Word War II has disproved

the existence of oil, even while the boring was carried to over a thousand feet in the hill No. 253 near Kali Mandir. Another deep boring for petroleum was made by the Burmah Oil Company (Pakistan Concessions) in 1948 at Lakhra about 40 miles north-west of Kotri beside the Dadu railway line; this penetrated Ranikot and Jurassic rocks, mostly shales, to a depth of 12,444 feet but without success. Only hot water and steam were met with and the well was abandoned.

(3) Iron Ore : Brown hoematite is found embedded in limestone and sandstone. At Tatta smelting of iron was widely practised in the past century.

(4) Road Metal: Limestone is generally used as road metal, but there is plenty of trap in the Laki Hills, though it is somewhat decomposed. A bed of trap 40 feet thick is found interstratified in sandstone above Hippuritic limestone on the hill called Bor, south of Barrah, 13 miles N. of Ranikot. Another band of trap is on *Cardita beaumonti* beds, stretching 22 miles from Ranikot to Jakhmari 17 miles south of Sehvan. It is 40 to 90 feet thick. The decomposed basalt contains nodules of quartz, chalcedony and calcite.

(5) Gypsum: Gypsum is found also on top of Gaj Hills in the Kohistan area.

(6) Clays: Coloured sands and clays, white, red, and brown occur in the Laki Hills near Bhagothoro.

(II) Economic Resources of the Lower Indus Valley.

(A) Western Valley Section.

(1) Agricultural produce: This is the mainstay of the region. Two crops are harvested as follows:

Juari		Wheat	
Bajri	Kharif	Tobacco	Rabi
Rice	(Summer Crop)	Barley	(Winter Crop.)
Cotton		Oil Seeds	

With a steady and systematic water-supply from the Lloyd Barrage great improvements are being made in these crops and fresh cultures introduced. The cotton has proved the best in the Indo-Pakistan subcontinent.

(2) Forests: Along the banks of the great river there is a luxuriant growth of riverian forests, some of which have extended inland along the *bunds* and canals. Occasionally a whole forest disappears as a result of the erosion of banks by flood waters. *Babul* (Acacia arabica), *Kandi* (Prosopic Spicigera), *Bahan* (Populus euphratica), *Tali* (Dalbergia Sissoo) and tamarisk (Tamarix gallica) grow plentifully.

(B) Eastern Valley Section.

(1) Salt beds: Capt. Baker in a letter dated 18th. July 1844 drew the attention of Sir Charles Napier to the existence of very extensive salt beds near Allah Bund connecting with the lower part of the Puran. From Raoma to Wanga Bazaar large beds of salt, 5 to 6 feet deep, were discovered by Mr. Hodges.

Within this area there are valuable salt deposits. About a mile east of Goonee and extending 20 miles by 15 miles, terminating at Kotri between latitudes 23° - 24° N. and near longitude 69° E., there exists a bed 3 feet thick nearly or 929,280,000 cubic yards the equivalent of 1,484,151,430 tons, if its specific gravity is 2.130. This bed was discovered by Lt. Burke, R. E., Executive Engineer P.W.D., Sind Division, in 1847, while travelling from Sind to Kutch. In a letter, dated 7th. March 1847, to Major Peat, Superintending Engineer, Sind, he described the bed as follows:-

"For the first few yards, it appears as a ridgy layer with bunches and is but a few inches in thickness; but the thickness rapidly increases, and the structure is so hard and crystallina that it required some little time and labour to detach the smallest fragment with the only available tool I had with me, viz., a strong hunting knife. The hoofs of a horse made no

impression on its surface. This was a sandy colour, owing to the presence of a very slight film of drift dust or sand, which has been absorbed by the deliquescent quality of the salt. Crystallised knobs or bunches, of the same exterior colour as the general bed, occasionally rose about the surface and a few of these, having been recently detached, showed the dazzling and highly crystallised interior structure of the mass; less homogeneous and compact but perhaps clearer and more brilliant than that of Cheshire, or of the Punjab."

Lt. Burke also secured the opinion of Surgeon A.H. Leith of the Bombay Medical Establishment, as regards the quality and utility of this mineral:-

"It is just the same as the salt obtained by evaporating sea-water - the salt that is called Bay Salt: it is not so pure as rock salt, because it contains a little sulphate of soda, very little and of no consequence and also some muriate of magnesia, which later renders it a little bitter, but it can readily be removed by washing the salt in fresh-water: but as it is, I have no doubt, it would find a ready market, for it is very much cleaner than what is made in the Government salt pans about Bombay."

No more is heard in recent years about this precious deposit which in the opinion of its discoverer: "Would supply a population of one hundred millions for one thousand six hundred and sixty two years, at an annual allowance of 20 lbs. per head."

(2) Fuller's Earth: There are intercalations of this clay in limestone on the slopes of the Ganjo Hills, near Hyderabad, and also in the hills near Sukkur-Rohri, Jheruck and Thatta. It is a pale greenish clay used for washing cloth, etc., and is also eaten by pregnant women as a sedative.

(3) Gypsum: Gypsum is found on top of the Gaj Hills in places 3 to 4 feet thick. Dr. Buist, in 1852, referred to these deposits as a mineral for making Plaster of Paris and using the same for casting lattices and open-work screens for ventilation on tops of doors.

(4) Pottery Clays: The pottery works of Hala, Hyderabad, Thatta and Jheruck as well as the encaustic tile manufacture of Bulri and Saidpur make use of these clays.

(5) Flint: Cores of flint occur embedded in Nummulitic limestones in the hills near Sukkur and Rohri.

(6) Agricultural Produce: Large crops of Wheat, *Juari*, *Bajri* Cotton, etc., are obtained.

(7) Medicinal and other plants : Plants yielding drugs, chemicals such as soda, gums (myrrh), dye-stuff, and tanning ingredients, grow in abundance.

(C) Deltaic Area:

Salt Deposits, Fisheries, etc.,: (1) Within some of the creeks there are salt deposits of (e.g.) Surganda salt beds, 7 miles on both sides of the Sir Creek. Captain Baker, Superintendent of Canals and Forests, in a letter, dated 18th. July 1844, to Sir Charles Napier, also referred to other extensive salt deposits near the Allah Bund in the southeast. "I take this opportunity of bringing to the notice of H. E. the Governor of Sind that there are pools and valleys, connected with the lower part of the Puran, abounding in pure salt; many of the pools near the Allah Bund contain superficial deposits of this substance; but Mr. Hodges, Assistant Surveyor who surveyed from Raoma to Wunga Bazaar, met with large beds of salt to a considerable extent, and five or six feet deep. Should Government consider the subject worthy of attention as a source of revenue, it would appear from Mr. Hodges' description that the salt may be obtained in almost any quantity, and of the purest kind." For several reasons, among which may be mentioned the opposition in their own interests of the Bombay, Cheshire and Liverpool merchants, these salt deposits were not utilised.

Another salt deposit of a similar character was noticed "in the delta of a classic stream - between the Gora and Koree mouths," by Lt. Burke in 1848. He thought it to be "a vast

and practically inexhaustible deposits". A sample of it was carried to Calcutta in 1855 as ballast in a cargo boat; later a company was also formed. The following is an analysis of the salts given for comparison :-

Salt	NaCl 2	MgCl 2	MgS0	CaS0
The above deposit	99.7352	0.2647	0.00	Trace
Cheshire	98.2500	0.7500	0.00	1.55
Lymington	93.7000	1.1000	3.5000	1.50

It is to be remembered that the younger Tertiary rocks also are impregnated with saline material from the original (connate) sea water in the sedimentaries.

(2) Saltpetre can be extracted from the soil impregnated with nitrogenous matter. It commanded some trade with the East India Co., in the latter part of the 18th century.

(3) Sea-salt: About 88% of Sind salt is obtained from sea-water, while only 12% from the Saran and Dilyar deposits on the edge of the great desert in the Desert Section.

(4) Pearl fishery, as a source of revenue, was known to the Ameers of Sind and the industry was also developed in the early British days: Mr. John Macleod, Collector of Customs at Kurrachee, in a memorandum submitted to Government on 31st. December 1847 says: "In the salt water inlets along the entire sea coast of Sind, a thin-shelled variety of the oyster exists, producing a seed pearl. It is most frequently found on mud banks left dry at low tides. The pearl is of very little value compared with that produced by the Ceylon and Persian Gulf Fisheries, the price of the latter ranging from Rs. 1,000 to Rs. 15,000 a tola while the former seldom realises more than Rs. 15 a tola. From the supposition that it possesses invigorating powers, it is used here chiefly as a medicine. The larger grains are occasionally made use of as personal ornaments: the smaller ones to intermix with the valuable Bahrein pearls, in

which manner they are kept in bags by the Bombay merchants, as a means of preserving their lustre."

Side by side with this, there is good scope for *sea fishery* on the Sind coast.

(III) Economic Aspects of the Desert Province.

The natron-producing lakes already mentioned are the principal centres of industry. The mineral is an impure sesquicarbonate of soda mixed with common salt, of which thousands of camel loads are exported from the *Dhands.* Cheroti or gypsum is also extracted from Ghulam Nabi-jo-Got, while *Khara Chaniho* or soda and trona (*chaniho*) are also found. Soda salts can be prepared from the ashes of the halphytes or natron-producing plants growing in the region by the process of lixiviation. There are also a few salt lakes in the southern portion of the Thar Parkar District besides Saran, Darwari and Gaganwari beds, in which salt is available.

Wherever rain water is lost more by evaporation than actual run-off, subsoil and internal lake brine yield salt which is merely arrested on its way to the sea. Brine-impregnated subsoil also yields common salt.

CHAPTER III

HYDROGRAPHY OF THE INDUS - ITS HISTORY, REGIMEN AND PHYSICS.

As Sind is a gift of the Indus, it is necessary to study its history, its regimen and physics, regarding the fertility of the land. The history of the Indus River is lost in the mists of time. A large part of the Siwalik deposits of the Outer Himalayas led the geologists, E. H. Pascoe and G. E. Pilgrim, to believe that there must have existed an old river in this region, called the Indo-Brahm by the former and the Siwalik river by the later, before the Himalayas came into being.

Geologists have also generally recognised that in Asia there is a general trend of East-West river valleys (e. g.) the Sangpo, Hwang-Ho, the Yangtze Kiang and the Si Kiang. The rivers of northern India in their early stages show the same tendency. There is, therefore, no doubt that there flowed, in the Indo-Gangetic depression, a single river, at first flowing in the S. E.-N. W. from Assam to Kohat along the foot of the Himalayas; but later its drainage was altered and broken up, with the rising of that mass of Tethys Sea further and further back and helped Sind to come into being.

The Parent River: "The peculiar character and distribution of the Pleistocene Boulder Beds of the Siwalik series are capable of explanation only on the supposition that they were laid down in a rock basin, formed in the valley of a large river by upheaval and the consequent formation of a dam across its course. Since in Jammu and Kangra these boulder beds attain the enormous thickness of 5,000 feet and disappear quite suddenly to the N.W.

of this area, while to the S.E. they gradually diminish in thickness and are feebly represented as far as Bhutan, it follows that such a dam must have been situated N.W. of Jammu and that the river flowed along the foot of the Himalayas from S.E. to N.W. In Eocene times, when the sea covered the whole of the Western Himalayas, such a river must have risen on a watershed connecting the Rajmahal Hills to those of Shillong and the upper valley of the Brahmaputra, and continuing into China. A tributary of this river, draining the Eastern Himalayas, may, at a later period have become the main river of northern India. The author considers that the complicated drainage system and breadth of the Mahanadi so disproportionate to its length, as well as the entire absence of any fluviatile deposits older than sub-recent, such as we find on the Irrawaddi, point to Pliocene submergence of much of its former valley and to a much wider extension of the India peninsular, over which is now the Bay of Bengal, from the Eocene onward, than is the case to-day. Therefore, powerful rivers flowed south rising on the same watershed which is mentioned above. These may have cut back through it so that when a final uplift, on a more colossal scale than any that had preceded it, actually reversed the flow, the water flowed into the channels of the southerly flowing rivers which were ready to receive it. The V-shape of many of the Himalayan rivers along a certain portion of their course (the point of the V facing N.W) is significant as evidence that the northern arms of the V's represent tributaries flowing in the normal direction which they would take to join a great north-westerly flowing river. The Gangetic alluvium, thick though it is, has all been deposited later than this period in the valley of rivers with a normal gradient, as the result of annual floods depression continuing simultaneously with the addition of flood material and sediments."

Discoveries of the John Murray Expedition: This theory of the Siwalik river bed may probably gain some support by the

observations of the John Murrary Expedition of 1933-34, in exploration of the continent of Lemuria or Gondwanaland, which is supposed by geographers to have once existed in the region now occupied by the Indian Ocean and other connecting waters. Not much light could be thrown by the explorers in a single exploration on the matter of such a vast continent, but the existence of *certain submarine ridges and gullies* has led them to believe that there was an extension of the mountains of the Kirthar and the Aravallis system together with *a huge river valley, which have now gone down into the northern parts of the Indian Ocean.*

Subsidence of the End Portion of the Indus Valley: Lt. Col. R. B. Seymour-Sewell, the leader of the Expedition, described in a statement to the press:-

"Between Ras al Hadd and the Indian Ocean in the neighbourhood of Karachi the echo-sounder clearly revealed the presence of a submarine ridge that runs westward towards the entrance, to the Gulf of Oman, more or less parallel to the hill ranges of Baluchistan and Makran. To the south of this ridge and separated from it by a level plain with a fairly constant depth of 1,850 fathoms lies a second ridge that runs towards the southwest, and immediately to the southeast of this is a deep gully, bounded in its turn by the edge of a plateau that slopes gradually downwards towards the southeast.

"The bottom of this gully lies 2,000 fathoms below the surface of the sea and its general character reminds one strongly of a river bed. It seems to me that we have here either the now submerged bed of the Indus where it flowed into the Arabian Sea along a line to the northward of its present course or perhaps the mouth of the great Indo-Brahm river, the existence of which was postulated by Pascoe and Pilgrim."

It is, therefore, probable that the Indus had its connections with the ancient drainage of the Indo-Gangetic plain in the

pre-Himalayan epoch, and that a part of the river system foundered with the subsidence of the Gondwanaland.

A GEOGRAPHICAL ANALYSIS OF THE LOWER INDUS BASIN

Breaking up of the River: Introduction. When the process of the upheaval of the Himalayas finally ceased in the north towards the end of the Pliocene period, this great river must have broken up into two systems, viz., the Indus with tributaries on one side and the Ganges on the other.

The Process of Severance: How this severance of the Siwalik river into the Indus system and the Gangetic system took place, is an interesting history. D.N. Wadia states:

'The most important post-Siwalik event was the dismemberment of the channel of the great Siwalik river, which hitherto had flowed in the northwest direction from its head waters near Assam, through the whole length of India of Potwar, and thence to the head of the receding Sind Gulf. The differential earth-movements which elevated the Potwar basin into a plateau, converted the northwest section of the channel into a separate independent drainage basin, with the Sutlej as its most easterly tributary. Hitherto the combined river had travelled to its confluence with the Indus along a track which was a northwestwards prolongation of the present course of the Jumna, thence via the present bed of the Soan, to the Indus in the vicinity of Makhad. After these elevatory movements and the separation of its N.W. section, the remaining upper portion of the main channel, according to the views of Pilgrim and Pascoe, was subjected to a process of reversal of flow, its waters being forced back by the Potwar disturbance to seek an outlet into the Bay of Bengal along the aggraded, more or less levelled sub-montane plains. In this process of reversal Sir H. E. Pascoe attributes the vigorous young affluents belonging to an opposing drainage course cutting back, beleading and capturing piece by piece, the main channel and ultimately deflecting its waters to the new

channel with a reverse direction of flow. This severed upper part of the old Siwalik river became the modern Ganges, having in course of time captured the transverse running Jumna and converted it into its chief affluent. The transverse Himalayan rivers which are really the oldest water-courses of North India, older in many cases than the mountains they traverse, continued to discharge their waters into this new river irrespective of its ultimate destination, whether it was the Arabian Sea or the Bay of Bengal. During the Upper Pleistocene epoch some interchange took place between the easterly affluents of the Indus and the westerly tributaries of the Jumna, by minor shiftings of the watershed, now to one side now to the other. There are both physical and historic grounds for the belief that the Jumna, during early historic times, discharged into the Indus system through the now neglected bed of the Saraswati River of Hindu traditions, its present course being of comparatively late acquisition.'

The present dry beds of the lower parts of the Ambala streams, and also those of the Gaggar, the Hakra and the famished condition of the Eastern Nara, and other *Dhoroes* in Eastern Sind, with a large number of ruined towns and villages now buried under sand along their channels, are other indications proving that there must have passed through these desert tracts in former epochs a large river which made them fertile and prosperous.

The diversion of drainage from the Indus to the Ganges must also have been gradual. A certain species of dolphin lived on fresh-water food in the original river. Then when a depression between Rajmahal and Assam took place, and the drainage partially escaped into it, this fauna must have also passed into it. R. D. Oldham holds very strong views regarding the original westward flow of the Jumna and Gangetic system. He says, 'The diversion of the drainage from the Indian Ocean to the Bay of Bengal must have been a gradual process, whose final stage, the

permanent diversion of the Jumna into the Ganges, may even have taken place within the historic period. Before this, the waters of the Jumna must have flowed alternately into the Ganges and the Indus, or that dry river channel which can still be traced through the desert. In its latest stage, it probably, like the Casiquiari in South America at the present day, divided its waters between the eastern and western drainage, but now no further change can take place, for the river has cut its channel deep below the general level of the plain, and must perforce remain a tributary of the Ganges.' Thus the Indus system became quite independent from the eastern drainage system, and remaining partly antecedent (i.e. pre-Himalayan) and partly consequent (i.e. post-Himalayan), it has cut its own course through the mountains after the first uplift in the Pliocene age. During still later periods, this great river has helped the formulation of the Indus plain, both in the Punjab and Sind, in which process all its tributaries, the Punjab rivers, have taken part. De-gradation of the upper reachers and aggradation of the lower ones continue constantly.

The Indus in Sind: The Indus in Sind is the lower part of the Indo-Brahm, ultimately falling into the Arabian Sea, while the Indus of the Himalayas is an old tributary of it, discharging into it at Attock. As it is now in an exceedingly aggraded stage, its present channel through Sind is not the same as it was in post geological and early historic times. It might then have flowed through the present desert region straight into the Koree Creek, because of the greater volume of water than now. The eastward position of the sub-merged Indus gorge in the Arabian Sea and the physical features of Cutch also indicate this course of the river during the Pleistocene period.

The source of the Indus was discovered in 1907 by Hedin in a sacred spring, called the Singikabad, near the Manasarover lake on the north side of the Trans-Himalayan Range, N.N.E. of Kailas and 16,946 feet above sea-level. This position of the

source, in a lacustrine region (lat. 32° 20' N., long, 80° E. in the heart of the snowy peaks), suggests that the birth of the river must have been antecedent to that of the Himalayas. Had it been a consequent stream, *after* their upheaval in later ages, it would have flowed directly south. As it is, it takes its original course still further towards the N.W. for a considerable distance. While it emerges thus from the glaciers of the great group of Kailas Mountain peaks, it secures the waters of three affluents: (1) the northern tributary pointing the road from Ladakh to the Jhalung gold-fields; (2) the southern Ghar forming a link in the great janglam, connecting Ladhakh with Lhasa and China; and (3) the Shyok and the Shigar together with innumerable glacier-fed streams. So far the Indus has travelled through 530 miles of its bed between the grand chains of Ladakh to the north and the Zaksar Range, which is the main snowy range of the Himalayas to the south. Except for a short distance to the S. W., it pursues its usual course in a N. W. direction. The combined stream then reaches the Rakaposhi Peak. Here the Indus turns to the S.W. for the last time, and piercing the mountains transversely between Gilgit and Hunza, drops suddenly from its height of 15,000 feet to 4,000 feet level.

Soon it touches the Gilgit stream, emerging as it does from perhaps the grandest gorge in the world. Thus nearly 500 miles of surpassing mountain scenery are passed in north Kashmir. Only a few miles below this, the Indus crosses the mountains of Kohistan and Hazara, receiving its tributes from either side, until finally it advances into the Punjab plains below Darband in the latitude 30° 10' N and after flowing for nearly 850 miles from its source.

So far the Indus has received only the drainage of the Himalayan mountains. At Attock the Kabul brings down waters from the Hindu Kush and then the Kuram, the Tochi, the Zhob and the Gomal from the Suleiman ranges bring their share. Although still some 2,000 feet above sea level, the Indus here

becomes a navigable river, having left its rapids and deep wild gorges behind. 450 miles further south, the accumulated waters of the *Punjab* (five rivers) of the Punjab rush into the Indus River.

Lower Reaches: As the numerous tributaries of the river in this lower stage flow through drier and drier areas, they become smaller and smaller and their currents become slower and slower. They have to abandon old aggraded channels and cut new ones through their own deposits of mud, sand and gravel. While in their upper reaches they have had deeply fixed channels, in this lower plain stage even in the Punjab they have their varying sand-banks and stifled watercourses. Thus, on both the banks of the present Indus bed, numerous ancient channels of this kind have been discovered in the plain areas from long stretches of coarse gravel or sand-banks.

Entry into Sind: The single stream, thus strengthened at one point and starved at another, and still called '*Darya*' or sea, by the local inhabitants, now enters the province of Sind. Instead of increasing in volume it now dwindles down to less and less with its basin narrowed down and its affluents growing insignificant. It receives no tribute from any prominent perennial stream in the long stretch of over 300 miles in Sind, as there is little rainfall on the Western Highlands and the surface drainage is so poor. Its entry into the province is now heralded with a rush through the gap or gorge between Bukkur and Rohri in the limestone rocks. Here the topography is quite peculiar:

"The Indus in its course through Sind", says R. D. Oldham, "flows between banks that are raised above the general level of the country which slopes away on either side. This is a feature common to all rivers which are raising the level of their alluvial plains by the deposit of silt; but at Bukkur, the Indus exhibits a feature which is exceedingly rare if not without a parallel in the case of any other river, for, here it flows at the higher level

through a gap in a range of hills surrounded on either side by alluvium at a lower level than that of the river where it passes through the gap".

After this rush of waters through the gorge, a comparatively calm flow in the S.W. direction with the two arms, the Eastern and Western Naras, is now assured. The overflow lake of Manchar, with its safety valve, the Aral River on the right, and the various old channels of the Puran, Dhoro Naro, Gungro, Fuleli and Pinyari into which it rushes during the season on the left bank, help to complete the picture of the Indus in its lower basin. By this time the stream has changed its direction of flow to southeast, till it reaches Kotri. Another curve round the rocky Kohistan defile in the S. S. W. direction and through a more or less defined channel, fed by a single hill torrent, the Baran, brings it down to Thatta, below which it is split up into several branches, small and large forming the delta.

The Deltaic Stage: At Thatta, the river can be said to have entered the delta proper, though in recent geological times the mouth of the Indus can be located somewhere near Hyderabad. All land below this old capital of Sind is an area reclaimed from the sea. The land is so low that even now tide waters sometimes reach Thatta, although the sea is 60 miles away. Devoid of any hard rocks like the Sind Tertiaries, and largely covered with alluvium, sand hills and bars, mangrove swamps, etc., this area is generally uninhabitable. The coast-line also presents a chain of tidal creeks and scalloped inlets, which quickly silt up, leaving no hopes for a stable harbour. So great is the force of the inundation that it is not possible to have any river ports on the actual coast, but they may be traced inland, about 20 to 30 miles distant from the sea, on one of the side branches or distributaries.

Now advancing southwards and now southwestwards within the track of the S.W. monsoon, the river finally merges into the Arabian Sea, though not without a second trubulent period of

giratory streams and violent swells near the coast. Its famished conditions in Sind coupled with the fact that the river has, long since, reached its highest stage of aggradation, is responsible for its present state of alluviation and its effects in Sind.

Outlets and Effluxes: The present outlets of the Indus on the left bank are (1) the Fuleli of Hyderabad and further down called the Guni, the Pharan and the Kori, and (2) the Pinyari east of Jheruck and later on called the Gunra and the Sir.

The present effluxes are the Oclito and the Haidari. The following are the 13 mouths of creeks discernible in modern times:- Sir, Pakhar, Kajhar, Kharak, Kahr, Kalandri, Turshian, Hajamro, Sisa, Dubbo, Pitiani, Khudi and Pitai.

Thus the whole river as it exists to-day, has a long and chequered career of about 1800 miles, through varying topography and valley stages.

THE REGIMEN OF THE INDUS.

The river is fed both by rains and snow, and its periodic floods are the most important phenomenon of the Indus regimen. They have been looked upon by the people from times immemorial as events of great moment to the province.

On these annual swellings and inundations has depended the prosperity of their fields. Had these inundations been regular, uniform and universal in the whole basin, the stability of the fields would have been assured. But the vagaries of the Indus are great. Once it takes to a bank, the left or the right, it sticks to it for some time; then it changes its direction. At times it also changes its bed and effluxes, and brings different fields successively under its sway. The inundation is not always general but partial, the whole area is not submerged but only portions are flooded at a time. The result is an irregular distribution of waters in the region year by year. In fact, during all these ages there is no part of Sind except Sind Kohistan that has not been watered by the Indus at some time.

In a single year, the quantity of water also fluctuates. During the cold season the river dwindles to a shallow stream, the Bukkur guage reading as low as -2.40 feet at times. By March and April the snows on the Himalayan heights begin to melt and the stream is refreshed. After a temporary fall for about two months, the river again becomes fuller and fuller until the inundation reaches its climax usually in August, when most of the snows have melted away and the lower ranges of the mountains have also received their share of the monsoon rains. More than the silt brought down by the current, the waters of the river are themselves valuable, so that when a second and more powerful monsoon wave comes on during the season, not only the soil gets enriched with silt but the parched land and dust of the desert also are enlivened. These flood waters inundate the neighbouring alluvial plains and fill all the canals, distant and near.

Thus like all great rivers fed by snows as well as rains, the Indus has great variations of flow from year to year and month to month. At times the waters do not rise till the beginning of April and the great flood does not come before September. In some years the Bukkur guage does not show a reading higher than 12.7, while in other years, there can be an extraordinary rise of 19 feet above the lowest water-level of the year. Meteorological conditions also exercise some influence over the river regimen. Both the snowfall and the rainfall being variable here, there is no knowing when the Indus will have a normal flood and when an abnormal one. There is, again, a wide margin between bad and good floods in Sind. The causes of this condition are to be traced to the geographical position and climatic conditions of the upper Indus region. The snow-feeding of the Indus has been referred to; the Sulej is another great snow-fed river rising in the Greater Himalayas and pouring its waters into the Indus. Other Punjab tributaries of the Indus are only partially snow-fed and principally rain-fed.

Some of the tributaries of the Indus rise beyond the Siwalik hills of the Himalayas and these are fed regularly by the S. W. and N.E. monsoon currents. These drain the whole area within the monsoon zone, and showers over only a portion of the upper Indus basin are bound to give it an impetus. At times and during cyclonic storms there is exceptional rain-fall in the Lower Basin.

For this alteration of high and low floods, we take the Bukkur guage as the basis for discussion. It is a point on the river course conveniently fixed in a gorge and the whole flood of the river passes through it. Lower than this, the flood level rises above the general level of the country and so the plains are flooded and lands frequently destroyed. The whole run-off of the rain-fall within the catchment area and the melting of the snows are secured at this guage.

Another suitable guage for the sake of comparison is the Kotri guage; this is the other fixed point on the river course near the Laki Range, and the readings are quite accurate and reliable.

RESEARCH DONE BY THE INDUS RIVER COMMISSION: The observations of discharges, silt deposit and transportation of sediment, etc., taken by the Indian River Commission from January 1901 onwards, at these two and other stations are of great scientific value. They give valuable information regarding the flow and action of the Indus waters from year to year and day to day.

Guage Readings: A reference to the graphs of these gauge readings at Bukkur (Sukkur) and Kotri from year to year will show the seasonal rise and fall of water-level. From the extreme shallowness of the river during the months of December and January, the river takes a turn about the middle of March when the snows begin to melt on the mountains. In April the gauge level reads +15 feet at Bukkur, a difference of 16 feet over the

winter gauge reading, and +20 feet at Kotri gauge, a difference of 15 feet. Then with a short pause in May and some part of June whenever the monsoon season is delayed, the river rises steadily until it has its maximum flood level in August. Later the level falls rapidly until at the end of the year the gauge again sinks to the bottom after some fluctuations in winter due to rainfall from western depressions. Thus the gauge readings are affected every year visibly at three different times: (1) at the beginning of summer when the snows melt, (2) the summer rainy season, and (3) the winter rainy season, the predominant factors being snowfall on the Himalayas and rains in the Punjab and Sind.

The following is a summary table of the annual rise of water-level at Bukkur (Sukkur) and Kotri for a period of 15 years and their averages.

For the same reasons, the annual rise and fall of water-level at Bukkur (Sukkur) as well as at Kotri vary from year to year. Readings obtained by the Indus River Commission for a period of 29 years (1902 to 1930) reveal that the level rose to 17.70 feet (max.) and fell to -2.40 feet (min.) with an average of 15.24 feet mean (max.) at the former station, and to 24.88 feet (max.) and 3.70 feet (min.) with an average of 20.88 feet mean (max.) at the latter station.

Annual Rise of Water-level in feet (Sukkur and Kotri Gauge)

Average of 15 years	SUKKUR			KOTRI		
	Max.	Min.	Rise	Max.	Min.	Rise
1916 to 1930	15.24	– .70	21.9	20.88	5.58	16.06

Out of these years, 11 were actually those of low floods.

The River Discharge: Discharge, also varies from year to year and season to season.

Discharge Observations of the Indus at Sukkur

Average of 10 years.	Max.	Min.	Width of water surface feet.	Mean vel. per sec.	Cub:Ft. discharge per sec.	Wind Directions	Wind vel. ft per sec.	Rainfall
from 1911 to 1930	—.2	15.12		5.01				2.76
Discharge Observations of the Indus at Kotri								
from 1911 to 1930	5.6	21.63						2.77

Factors of Discharge: It is clear from the discharge observations that the discharge varies greatly and that, at neither of the two places does it correspond with its rainfull for a particular year, proving thereby that snow-melting and rainfall in the upper regions are large factors in the total quantity of water entering. Additions from rainfall in Sind are quite negligible; for example, the maximum rainfall of 11.10 inches at Sukkur for 1929 did not show the maximum discharge at the gauge, but on the contrary 108,033 cusecs less than that of the maximum which was in 1914, when the rainfall was the least viz., .48 inches, the discharge was 683,581 cusecs, that is 253,136 cusecs more than that of the minimum which was in 1915, when the rainfall was 1.44 inches. So also at Kotri, the max. discharge was 532,383 cusecs in 1924, when the rainfall was only 12.07 inches, that is, 26301 cusecs less than in 1929 when the rain was the heaviest, that is, 23.12 inches.

Sometimes the Baran below Kotri adds a good discharge to the Indus.

In this respect, the Indus differs greatly from the Nile River which is mainly rain-fed. Ordinary meteorological conditions do not affect our river so greatly as the Nile, where it is possible to predict high or low floods to a certain extent.

A diminution of measurable discharge at Kotri compared with that of Sukkur is noticed from the data given above and the reasons are :-

(1) Loss by evaporation

(2) Draw-off by canals

(3) Loss by percolation.

In the above figures for Sukkur, no allowance has been made for 'Lag' and withdrawals en-route from Mithankot to Sukkur. The difference gives an idea of the quantity of water available for irrigation in Sind.

How much of the flood waters is due to snows and how much due to rainfall, it is difficult to decide. But for the sake of comparison, the following table of Discharge Observations at Punjnad, a station above the confluence of the five rivers entering the Indus has been given. Even these figures include the waters of the Sutlej, which is, as has been stated above, also a partially snow-fed river. It is, therefore, impossible to eliminate altogether the Punjab rivers' share.

Discharge Observations of the Indus at Punjnad (Daka)

Year	Min.	Max.	Width of surface	Mean vel. per sec.	Discharge per sec.	Wind direction	Wind velocity
1929	0.82 (16 Jan)	13.80	1,179	0.43	6166	E	Slight
	28 Aug.		1,996	6.04	137882	...	Calm
1930	1.82	11.21	1,335	0.41	5,360	NE	7.83
	(10 Jan.) 23 June		1,928	4.22	101,121	S	12.30

It is to be noted that while the waters derived from the melting of the snows come down gradually, those of the monsoon rains descend suddenly and cause anxiety about breaches of bunds and destruction of the country-side by floods.

Silt Deposits

Quantity of Water and Total Volume of Silt passed down the Indus.

(Average of 29 years)

Year	Sukkur			Kotri		
	Discharge in mill. cub. ft.	Silt in mill. cub. ft.	Average silt in grains p' cub. ft.	Discharge in mill. cub. ft.	Silt in mill. cub. ft.	Average silt in grains p' cub. ft.
1902-30	147,327,842	288,182	37,545	124,516,586	255,550	39,364
	5,080,270	9,937	1,295	4,293,672	8,299	1,357

Observations: It will be seen that while, on an average, the waters at Kotri are more silt-laden than those at Sukkur, the total volume of silt carried down below Kotri is smaller than that carried down below Sukkur. The difference represents the deposit of silt on river-side banks and fields irrigated by all canals. The silt thus lost between Sukkur and Kotri during the 29 years amounts to about thirty-five thousand million cubic feet, which is equivalent to about 1,300 square mile-feet. The volume of silt passing below Kotri in 30 years is about 9,100 square mile-feet. An analysis of the silt carried shows almost equal parts of sand and silt. The following are other observations made by the Commission on silt deposits:-

"The minimum amount of suspended matter is carried near the surface and the maximum amount near the bed of the river. Any variations from the general rule are probably due to disturbances, such as upward currents eddies, etc. Strong winds are also an external cause affecting the result as they blow sand into the river. Generally the amount of silt varies with the stage of the river; the higher the gauge reading, the greater is the silt in suspension. Noticeable features are the large increase in the quantity of the silt when the river rises suddenly and the large decrease thereof when it falls quickly. The quantity of silt carried by the Indus increases with fair regularity from May 1, when the river commences to rise, up to the middle or end of

September, when the river begins to fall; thereafter the amount of silt in suspension diminishes approximately, as the discharge decreases."

Variations in the Silt deposits

Maximum quantity of silt recorded

Max. quantity in grains per c. ft.		Date	Remarks
Sukkur	3,000	10th. Aug. 1907	River rising
Kotri	3,170	22nd. Jan. 1906	-do-
Dero	940	17th. Jan. 1908	-do-
Ghazi Khan		19th. Jan. 1910	-do-
Minimum quantity of Silt Recorded			
Sukkur	50	1st. Dec. 1906	River falling
Kotri	110	16th. Jan. 1908	-do-
Dero	20	28th. Feb. 1908	-do-
Ghazi Khan			

The maximum quantity is when the river rises and the minimum when it falls. Also the silt is less at Sukkur than at Kotri.

Sir John Ottley, Inspector-General of Irrigation has drawn the following conclusions:-

1. The quantity of silt increases according to the depth below the surface.

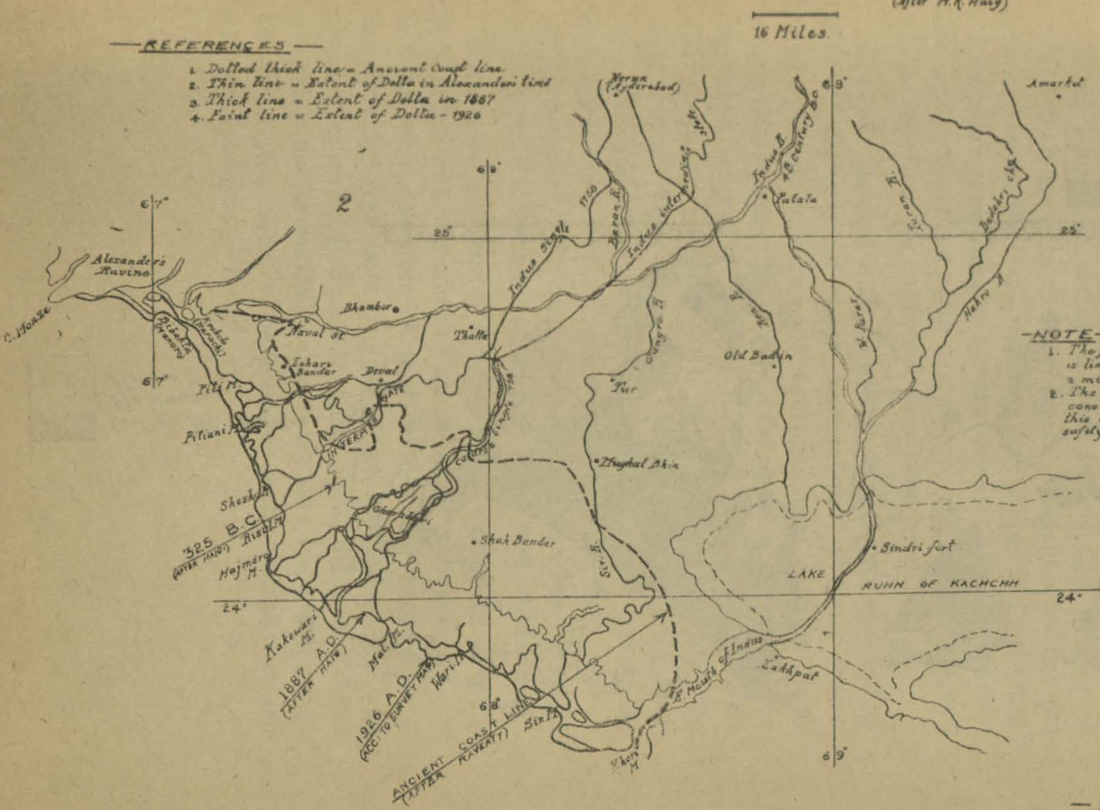
2. There is more silt in a rising flood than in a falling one.

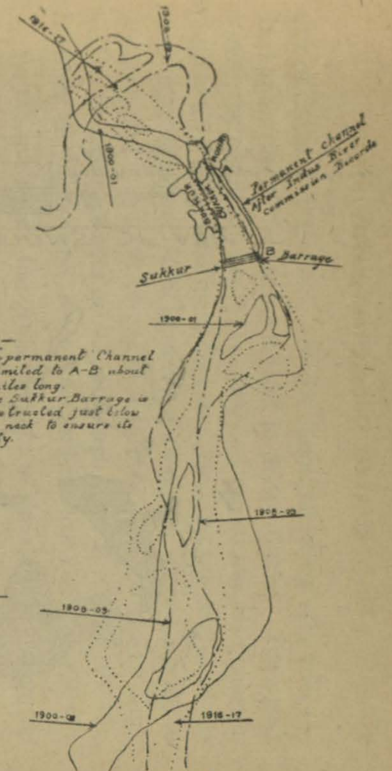
3. The maximum amount of silt is carried when the flood has reached 2/3 of its height.

Effects of Silting: This variation in the discharge of waters between high and low flood seasons and the amount of silt carried during the year produce great effects on the Indus channel. They change its momentum, which in its turn causes bar crossings, spills leading to cut-offs and the consequent instabi-

MAP SHOWING HYDROGRAPHICAL & OTHER CHANGES IN THE INDUS DELTA

(After M.R. Haig)





—THE INDUS—

— SHOWING OSCILLATIONS ABOVE & —
— BELOW THE BUKKUR GORGE —

lity of the river regimen. The silt deposited being very fine, the bed and sides of the channels yield to flood attacks. The result is that the gradient, depth, velocity and the course also change, the bed level rises, the meanders increase and the course of the river is lengthened. Old land is cut away first on one bank and then on the other, and new land is formed on the opposite bank and so the tortuousness grows, although there is a limit to this between the higher and lower level and the low riverain tracts.

At the same time the great advance of the rich silt deposits of the river during its passage through Sind is that the soil is periodically renewed in its upper layers. The silt covering the fields makes excellent soil, requiring little tilling and manuring, and crops are grown regularly every season. After the harvest time, as the waters rise again next season, the soil gets renewed and becomes fresh for cultivation once more.

Need of a Barrage in Sind justified: A river with such irregularities of discharge of water, uncertainties of flood season, regimen and silt deposits, and hydrographical changes would never make the irrigation system in the region a steady success. Irrigation could only be done by inundation canals, during the flood season, and by lifting water from wells, etc. during the winter season. There was a great wastage of water in the monsoon season and a barrage across the river at a most convenient point, where the bed of the river was more or less fixed, was an absolute necessity. But even the safety of such a barrage would be in danger, if the physics of the river is not well understood.

Changes in the Course of the River: Such a complicated channel of waters with such varying velocities, silt deposits, etc., as the Indus must, therefore, have its bed, in the valley of Sind changed at different times. Any appreciable stretch of land covered over with coarse gravel, called the *Khaddar*, on a level higher than the surrounding country, is a sure indication of an abandoned river course. The following shows evidence of old beds of the Indus:-

1. The submerged ridges and gully in the Arabian Sea, discovered by the John Murray Expedition of 1933-34, point to a course of the river, in recent geological times, not wholly identical with that in existence at present.

2. There being very few solid rocks in the lower part of the valley itself, there are no landmarks such as deserted gorges left by the river. But the old gorge at Aror, 4 miles east of Rohri, is a distinct proof of at least a portion of the Indus having flowed eastwards beside the ruined city of the ancient Hindu kingdom of Sind. This shows that on occasions the Indus can even break through solid rock.

3. Among other less durable landmarks may be mentioned the ruined cities of Mohen-jo-Daro, Bahmanabad, Debal, Patala etc., some of which are hard to trace in the alluvium, under which they have been buried. It is certain that such cities could never have existed without a constant source of water-supply as from a large river in the absence of sufficient rainfall. Old abandoned water channels such as *Dhoroes*, have been traced near them even at this late date.

4. *Westering Tendency :* That there is a distinct westering tendency of the Indus in Sind at present is shown by the numerous *Dhoroes* found in the Eastern Valley section. According to Parkar's observation, 'in the Northern Hemisphere rivers flowing to the north attack the east bank and those running to the south the west bank (i.e.) the right bank'. The same effect may also be due to the rotation of the earth but here the assumption that the water of the river does not acquire the same rotatory motion as does the land is unwarranted. It is not in all times that the Indus has westered.

This present westering tendency has been clearly marked in the now starved stream of the Fuleli and the flow of the Indus on the west of Hyderabad from about the year 1758 A.D.

Except Bukkur-Sukkur and Kotri, there are but few other

points in the course of the Indus in Sind, which may be considered to be fixed. Beyond Sehvan, the river can no longer 'wester' now, due to the higher levels of Kohistan. But there is, so to say, not an inch of ground in other parts, which at one time or another has not been watered by the river. Old beds and forsaken channels are common features of the region.

5. The S. S. W. trend of the Indus delta is another important evidence to show the shifting nature of the river, even in its deltaic stage. An examination of the maps prepared by Carless, Wood, MacMurdo, Haig and others distinctly shows that the delta has been growing towards the S. S. W. direction and more and more outlets of the river open out here in a network of many tidal creeks of varying shape and situation. Many collateral branches of the Indus have appeared at one time and disappeared at another.

Causes of the Changing Hydrography : (1) We have already stated that the Indus in its Lower Valley stage is an aggrading river and silting is an everyday occurrence. Such a river with its actual bed on a level several feet higher than the surrounding country is bound to wander about and seek fresh channels every season. A reference to the charts of the river channel prepared year by year and published in the Indus Commission Records, shows that in no two seasons is the river channel in some reaches marked the same.

2. The friable nature of the soil is another cause. Large masses of it are displaced and dragged away by the stream in the flood season. More than the fine silt and clay, the shifting (blown) sands and sandy clays help it greatly to fluctuate. At times the whole channel is silted up and a fresh one formed.

3. Periodic floods and inundations with the consequent breaches of *bunds* are also another cause.

4. The fall of the country to the south is only a few inches per mile. This makes the region virtually flat and the river

could not be confined to one definite bed without marginal *bunds*.

5. It is argued that seismic disturbances play some part in changing the beds of a river. The Aror and Bahmanabad catastrophes are ascribed to an earthquake by historians of Sind. Geologically it is open to doubt whether earthquake shocks are capable of diverting the entire course of a river, although locally they affect it to some extent.

6. The continuous growth of the delta may have something to do with a change in the hydrography of Sind. Thatta, miles from the shore line and until recently the apex of the delta, was left in the background about 150 years ago. The Ren was dried up in 1857 A.D. The whole Indus, north of Thatta to Gharo, is scalloped with inlets of the sea, which before were outlets of the great river. The principal channel of egress about the year 1809 was the Bagar, in 1831 it was the Satar, to-day it is the Haidari.

7. Lastly, a change in the hydrography of the Punjab must affect the river in its lower levels. There is no doubt that some of the Punjab rivers e.g., the Ravi, the Bias, and the Sutlej have changed the courses even in historic times. The Indus draining all of them, even before it reaches Sind, is constantly disturbed by them. Multan, Uchh, Harappa and other old towns have been thrown, within recent times, out of the influence of the Punjab rivers. The drying up of the Saraswati-Hakra-Gagger river system has definitely affected the natural drainage of Sind.

Thus the Indus has been in constant danger of leaving its bed sometimes, except at the fixed points mentioned above e.g., Sukkur-Bukkur and Kotri. Even to-day with the approach of the monsoon season, the river causes anxiety to the Public Works Department, when it shows signs of pressing towards one bank or the other. This is especially watched in the region a little above the Bukkur gorge.

Such an event has already taken place in the past at Aror about the year 962 A.D. and a very good physiographical explanation of it has been given by R.D. Oldham.

"In former times the Indus wandered over the plains which surrounded the Khairpur Hills raising the level of the soil on either bank till it broke away in the low ground on one side or the other, and so by degrees raising the level of every part; during the latest phase of this process previous to the origin of the existing conditions, it flowed east of its present course and having raised the level of the ground there, wandered away westward; by this time the surface of the alluvium had been raised till it was level with a gap in the Khairpur Hills at Rohri, and as the alluvium south of the ridge would probably be at a considerably lower level than on the north side, the waters of the Indus having once found an outlet through this gap, would soon establish a permanent course for themselves. If then we assume that the other river (the Hakra) instead of depositing silt and raising the level of alluvium, was an eroding stream, we may suppose that it gradually worked westward till it reached the present situation of the Eastern Nara and excavated that channel; the flood waters from the Indus would smooth off the slope between them, and had the process continued, there can be little doubt that the Indus would soon have broken away into this low-lying channel, had not the other river (the Hakra) owing to a change of course in its upper reaches dried up before this happened."

An Indirect Advantage. Every evil has a blessing in disguise, and one great advantage of the vagaries of the Indus and its offsets is the vast area of cultivable land which can be commanded by its irrigation canals. This circumstance places Sind in a unique position among the dry regions of Asia. Its potentiality from the point of agriculture is very great.

PHYSICAL LAWS GOVERNING THE INDUS

That there are certain physical laws whereby such an alluvial river as the Indus frequently breaks through its banks and changes its bed cannot be denied. In this respect this river resembles other alluvial rivers such as the Mississipi, the Amazon, the Hoang-ho, the Ganges and the Irrawaddi in their lower reaches. An authority on this subject says:

"A main river of the class under notice might be expected to run in a more or less straight course, were it not that it is under compulsion to co-ordinate its velocity to what the materials of its bed and banks can best stand upto. But on account of the caving and other kinds of erosion made possible by the relative incoherence of the soil, the thread of the main stream lengthens itself by bending until its velocity tends to approach that at which caving and erosion will cease. If only the discharge of a river were constant throughout the year and in successive years, a time would doubtless arrive when bed, banks and current would have so far adjusted their difference as to arrive at stability of regimen. But such a state of things is rendered impossible by the periodic changes of discharge volume which are the consequence of rainfall or in India chiefly of the melting of Himalayan snows. The result of this instability of conditions is that permanency of regimen is never attained and so in the process of time the river is found occupying, in turn, each and every part of an area bounded by a certain pair of lines beyond which it never ordinarily wanders."

Molloy's Theory of the Indus: Mr. Molloy in his pioneer work on this subject has evolved a theory whereby he explains how the river happens to shift its bed, how to some extent this might be foretold, and how its effects may even be counteracted.

The following resume of Molloy's theory of the physics of the Indus has been given by F. J. E. Spring, Chief Engineer, Indian State Railways:

"The extent of mischievous erosion at any given place depends on the quality of the soil of that place and on the velocity of the current. The quality of the soil is pretty much the same everywhere on the length of the Indus under consideration, - that is, nowhere can it stand up against velocities greater than between about six and ten feet per second. But the velocity varies very greatly and local slopes varying from 1 in 2500 to 1 in 8000 are found not only in the low water but also in the high water season. It is important to understand when and where steep surface slopes may be looked for, so as to be able to anticipate and perhaps to prevent their occurrence, if it should prove worthwhile to do so, - that is, if there should be urban or irrigational interests worth the expenditure needed to prevent such occurrences. The incessant and often violent alterations in the surface slope are exceedingly perplexing; but they may almost always be traced to action on the mid-stream bars or crossings."

Oldham's Theory: R. D. Oldham, formerly of the Geological Survey of India, after his investigations of the river at Dera Ghazi Khan in 1902 propounded another theory, based on the Four Principles of M. Dausse, a French engineer.

"The Revenue Survey maps show that the Indus is alternately concentrated into a single channel and splits up into several smaller ones, that is, it presents the alteration of reach and 'fan'. (A comparison of maps of different dates would permit of an estimate being made of the rate at which they gradually encroach on each other.)

"If in one of the 'fans' there is or arises a solid obstacle not readily eroded by the current of the stream, it will have no effect so long as one of the minor channels of the 'fan' does not impinge on it. When this takes place, the current will be unable to remove the obstacle and the channel will be deepened by scour against its face, the current increase in velocity. owing to the increased depth of channel and erosion will be set up, which will

cut backwards into the 'fan'. Now the gradient of this channel of erosion is markedly less than that of the surface of the 'fan', and consequently as it cuts its way back, there will be a stretch of very steep gradient and excessive erosion at its head, the gradual deepening of the channel as it cuts back into the 'fan' will attract more and more of the water of the stream, till, it may be, that the whole volume is concentrated in a single channel thus establishing a 'reach' in the middle of what should be a 'fan'. The gradient of this 'reach' will be less than the average gradient of the stream, the slope of the 'fan' is greater than this average and consequently there will be violent erosion taking place near the head of the 'reach' which will readily cut its way upstream into the 'fan'."

Conditions in the Lower Indus Basin: The conditions in Sind, especially in Upper Sind, are similar to those depicted by Oldham for the district of Dera Ghazi Khan. The formation of 'reach' and 'fan' in turn, the increase and decrease of velocity of current, and the erosion of the bed and banks are generally in agreement with this theory. But there are a few local peculiarities in the flow of the Indus:

1. The Indus in Sind is running on ground higher than the land which falls on either side, so much is the aggradation taking place.

2. The cold weather discharge is the lowest in Sind.

3. The nearer the river approaches the sea, the more are its meanders and the larger the round bends, as the following table shows:

Successive 100 miles length		A-Length measured direct	B-Length measured direct	Percentage of Meanders.
1st.	100 miles beginning at the sea	72	100	39
2nd.	-do-	75	100	33

3rd.	-do-	72	100	39
4th.	-do-	69	100	45
5th.	-do-	82	100	22
6th.	-do-	82	100	22
7th.	-do-	93	100	7
8th.	-do-	98	100	2
9th.	-do-	97	100	3

As a result of this increasing tortuosity towards the delta, the river brings less and less water as it flows downwards.

4. The floods are heavier and so the changing conditions during the flood and the time when the river falls cause frequent cut-offs, erosion of bed and banks, etc.

Low and overtopping banks, ox-bow lakes and the ultimate cutting out of the narrow neck of land with the consequent shortening of the length of the stream, excess of velocity of the current - all cause flooding of the fields and erosion of banks.

5. There are only a few fixed points in the whole course of the river through Sind: at Sukkur there is a narrow gorge in the lime stone rocks producing rapids during the time of inundation, at Kotri where hard clay beds rest against gently dipping Kirthar rocks, and at Jheruck where masses of hardened banks protect the stream. At all other points the banks in the immediate neighbourhood of the stream are continuously undermined on the concave sides and aggraded on the convex sides of its wanderings. Thus old banks are destroyed in one season and new ones are made in the next. At times two sets of banks are clearly noticeable, viz., temporary destroyable banks a couple of miles apart and permanent ones as much as 15 miles apart.

River-training: Unlike the system of river-training in the Punjab, there are no elaborate works, such as the old-spur system or the modern practice of guide banks, undertaken in Sind,

to confine the current of the river to particular direction through a bridge or over a weir. The flood menace being the chief danger here, the Zamindars in the past used to protect their land by *Bannas* or small *bunds* round their fields. During the British period, however, elaborate river embankments have been constructed. To protect the country from devastation by flood or the river from eroding, breaches in the banks or in the canals such embankments or dykes have proved very useful. These '*Bunds*' are frequently strengthened or reinforced with loops after breeches are made in them by the river Indus. Even in the Eastern Nara Valley, expensive embankments have been built to retain the increased supply of water within the valley.

Some of the important bunds are as follows :-

Right Bank	Length in miles	Left Bank	Length in miles
Kashmor Bund	73	Naich Bund	34
Sukkur Begari Bund	46.5	Kasimpur Bunds	10.5
Ghar Canals	45.8	N. Sukkur	28.25
Nara Canals	77	Naplakhi (Bhroti) Bunds	8.92
Manjhand	5.75	Fuleli Canals	35.01
Karachi Canals	56	Karachi Canals	98
Total miles	304.05	Total miles	214.68

Safety of the Sukkur Barrage: As the site chosen for the Sukkur Barrage is the safest, the river having never left the bed just below the Bukkur gorge, where it is located, there are no chances of the river bed changing and of the Barrage works suffering. There are, however, chances for the river channel to break through the banks on the upstream side, i.e., 15 to 20 miles north of Sukkur. Here the river is trying to erode the bank and to cause a breach in the protective *bund*. During the flood season of 1935 some water did actually flow down the depression along the Eastern Nara (beyond Aror) and was probably absorbed by the desert sand. The usual precaution against

such breaches, viz., looping the *bund*, is taken. On the whole, the safety of the Barrage is now assured.

NAVIGABILITY

A discussion of the navigability of the river Indus is most valuable probably from the point of view of commercial intercourse.

History of Indus Navigation: A study of the latest archaeological discoveries in Sind tends to show that there was a possible intercourse by seas between the people of the Indus Valley (Mohen-jo-Daro) and those of the Sumer (Mesopotamia) by sea. Their influence had reached far inland, in India even to the banks of the Ravi and as far as Harappa at least. No doubt, the Indo-Sumerians utilised the waterway of the Indus to their great advantage and proved its navigability even in their earliest civilization.

The credit of directing the first geographical survey of the Indus is given to the Iranian sovereign Darius the Great, who employed his Greek engineer, Skylax, for the purpose. The wealth of geographical information, gathered by the Iranians, was then utilised by Alexander the Great, who ordered his navy down the Indus river under the command of Nearchus. Himself a great lover of martial fame, he created new cities such as Patala on the bank of the rivers and on its delta. Thus his was the first naval power established on the Indus and although his influence in the east faded soon after his death, a way for all European trade was opened by him. 'The march of Alexander the Great from the Beas to the ocean with the voyage of Nearchus marks the coming line of European trade with India'; and indeed for a long period intercourse between the east and the west flourished. 'The Indus trade route was a sheer necessity, because Mahomed wrested Egypt from the Byzantines and closed the overland route of Suez to the Greeks'; the Indus thus became 'a new channel by which the productions of the

East might be transmitted to the great emporium of the West'. Again, 'The rich and easily stowed products of India were carried up the great river as far as it was navigable, thence transported to the Oxus, down whose stream they proceeded as far as the Caspian Sea. There they entered the Volga and sailing up it, were carried by land to the Tanais (the Don) which conducted them into the Euxine Sea, where ships from Constantinople waited their arrival'.

This movement of Indo-European commerce continued in later times. Unfortunately the dark ages of Mediaeval Sind in succeeding centuries have left no historical records to show the use of the Indus as a navigable river. Now and again, as the Indus Valley came to be ruled by a multitude of fighting chiefs-particularly after the downfall of the Moghuls-the Indus was not used as a highway of commerce.

But the Sindhis were sea-farers; long before the advent of the British in Sind, about the thirties of the last century the natives used their craft. There was no dearth of native boats such as *Dundies*, *Jumptis*, *Zorrucks*, etc,.

British Surveys of the Indus: Lord Ellenborough was among the earliest Englishmen to discover the navigability of the Indus and to press the East India Co. to utilise it for strategic purposes. He ordered an expedition under Lt. (afterwards Sir) Alexander Burnes, who became the first British navigator of the Indus in 1831. With the excuse of sending a present of English horses and a heavy carriage to Ranjit Singh from His Majesty George IV, the British Government took the opportunity of exploring the river route to the Punjab. Burnes undertook to collect data regarding 'the depth of the stream, its facilities for steam navigation, the supply of fuel on its banks and the condition of the princes and people who possess the country on it'.

In this project Burnes succeeded well and preparing a Memoir on the Indus together with a Map, presented the same to Lord Ellenborough. The expedition utilised the *Pittee* mouth

of the Indus for their starting point and sailing in boats from Thatta on 12th. April, reached Hyderabad after six days' journey; thence via Sehvan to Khairpur and Sukkur, where they halted for about a month. They reached Lahore ultimately on the 18th. July. Thus the value of the Indus as a waterway was definitely proved by the British.

A scientific survey of the Indus from many points of view was soon undertaken by the British, and we have to-day the following excellent reports and memoirs, giving us an idea of the conditions of the Indus which were then prevalent:

1. 'Memoir on the River Indus,' by J.F. Heddle (May, 1836).
2. 'Memoir on the Delta of the Indus,' by Lt. T. G. Carless (Sept., 1837).
3. 'Report upon portion of the River Indus, surveyed in the years 1836 and 1837,' by Lt. T. G. Carless.
4. 'Report on the River Indus', by Lt. J. Wood, completed in October, 1838.

These give detailed information on the following important points relevent to our subject: descriptions of the collateral branches and sections of the Indus, observations on the periodical swell and the nature of the various mouths, navigation, boats of the Indus, soundings, tonnage, etc. On the navigability of the river, Heddle observes:

"The Indus steamer in which I embarked, reached the main stream of the river Indus, not by that embouchure by which the principal body of the water is discharged, but by the collateral branch, called Hujamree, which in maintaining the intercourse between the upper part of the Indus and the sea, answers the same useful purpose to navigation, in relation to that river, that is served by the Hooghly in reference to the Ganges."

On the navigable character of the whole river, Lt. Wood has given valuable information. According to his observation the facilities afforded by the river vary with the state of the bed of

the river and with the locality. Within the delta, navigability is difficult on account of the instability of the numerous channels, though there is a good depth of water in them; the passage between the delta and Sehvan is the best. Between Sehvan and Rohri or Bukkur and higher up, the depths are irregular ágain, although the river is well suited to navigation. This is restricted to some months of the year; during the rainy months the passage is actually hazardous.

A number of cross-river soundings taken by Wood revealed a variety of depths from half a fathom to six fathoms higher up.

On the whole, the depth of water in the channels throughout Sind and even higher up was sufficient for the whole year for navigation by country crafts. The average depth of the river, when full, was about 24 feet, and in the off-season about 9 feet. The greatest depth is recorded between Kalabagh and Attock, viz., 186 feet. The average width of the river is 680 yards. The fall of the river per mile is as follows:-

(Distance by the River.)

	541 miles	313 miles	87½ miles	unknown	
Mouth	6 inches per mile	8 inches per mile	20 inches per miles	?	Source

Prevailing Winds in the River Valley: The prevailing winds in the valley are:-

1. Southerly (monsoon) for six months, from April to September.
2. Northerly for the remaining six months, from October to March.

These help or hinder navigation to a great extent, as the season may be. The southerly winds are very strong and reach the interior of the Punjab but grow less and less strong as they go inwards; while the northerly winds are not so steady, but at times violent and very cold. There are occasional gales received

also from the south in the hot season and marked by cloudy, rainy weather.

Besides these, there are local light breezes along the banks of the river varying from place to place.

Difficulties of Navigation: The uneven depths of the river and some of its branches within the delta, the low or high nature of the banks and their instability, the pressure influences of the tide and monsoon winds, sudden rise and depressions in the channel due to rains or dessication and, above all, the loose and friable nature of the soil and the sand banks or mud-banks - all affect the navigability of the river.

Among other difficuties are those of finding the entrance through one collateral branch or other, of the shallow depth of water in the cold season, and the absence of suitable ports accessible to vessels of burden. While the river is broad and sufficiently deep from Hyderabad northwards, the channel from the seaboard to Hyderabad is not so suitable.

Present Conditions of Navigation on the River: The Indus has not been surveyed from the view-point of navigation in recent years. The railways, built by the N.W.R. authorities have displaced the only available waterway in the past, although it could be developed for native vessels side by side.

The conditions of the Indus, at present, cannot be very different from those depicted above: there is, however, no doubt that more and more silting has been taking place, making navigation more and more difficult, though not impossible, even for the high-sterned flat native boats which pass in and out of the river every year. During the winter season, however, the position is now different. The Barrage has actually created a high level of water in front of the gates - there is a difference of as much as 10 feet between the levels upstream and downstream, and very little water actually passes under the gates.

OTHER CHARACTERISTICS OF THE RIVER INDUS

1. *Difference between the Left and Right Banks:* The Indus has a comparatively shallow bed and undefined banks during the greater part of the year. In the season, when the level rises, silt deposits are laid layer by layer and the banks become higher and higher. Comparatively less silt is carried into the canals on the left bank than into those on the right.

It is also noteworthy that while on the left bank there are several old abandoned and tortuous channels with well-defined banks, there are no such channels noticeable on the right bank. This in the opinion of C. W. Tremenheere, who surveyed the area in 1867, is due to the enormous accumulation of deposits on the left bank and the westering tendency of the main stream.

2. *Indus Floods*: The river is well known for extraordinary floods.

Such floods were recorded in the years 1841 and 1858 in the past, and in 1928.

Recently some extraordinary floods have been recorded.

The rise of water a few feet in the river on its right bank, in July and August 1942, was disastrous. They covered nearly 16 Talukas in three districts, flooding altogether some 3,000 square miles, destroying roads, railways, bridges, culverts, villages, rice fields and farms, not to say much about the loss of innumerable animal and human lives. Then it was that some 400,000 people were homeless. There were actually three main breaches in the Begari and Jhali *Bunds*, hundreds of feet wide, a tremendous torrent (some 50,000 cusecs) with a fall of 50 feet, carried everything before it. The floods advanced as far as the Manchar lake and the Aral river, even 150 miles below Sukkur, and they too were not able to relieve the pressure soon.

History repeated itself in the Indus valley after 6 years, and this was the period I had predicted as producing peak years of rainfall, after studying the climatic conditions of Sind, which

are peculiar. Floods in Sind are a common feature ever since the days of Mohen-jo-Daro and Naru-jo-Daro, which themselves were destroyed by such disasters in prehistoric times. Even during the long historic period of nearly 3,000 years, the Indus has shown the same chronic malady. Indeed she seems to have thrown a challenge to man in this part of the world for all times: it is therefore a pity, a great pity that the warning given by me to the Sind engineers, after a prolonged study of the region, was not heeded. The special tribunal that tried the negligent supervisors of the Barrage canals under Sir Godfrey Davis, also failed to stir up the department sufficiently to avoid the disasters in future years.

Causes of Floods: The question is - could some of these disasters be avoided by man or not? The answer cannot be given without studying the real causes of the Indus floods, which are several:

I. Those that are emphemeral and can be controlled, viz.,

(a) Lack of very vigilant supervision and inspection of the engineering works, such as embankments or *Bunds*, flood gates, and flood levels.

(b) Construction of unsuitable engineering works.

(c) Imperfection in conducting river researches.

II. Those that are remote and cannot be easily controlled, viz.,

(a) The most erratic nature of the Indus. It has changed its courses innumerable times during its life history. There is much to be said and done about the instability of its bed, inequalities in the range of rise and fall, variations of discharge and silt and sand charge, disturbances of momentum, action of bars and crossings, etc.

(b) Westering tendency of the river. It has already been shown that the Indus, along with other Punjab rivers, has been westering. The distance estimated is nearly 30 miles. It cannot do

so now against the Sind Kohistan lower down, but in upper Sind and in the Sukkur-Larkana areas a number of *Dhoroes* or old channels have been noticed. Naturally, therefore, the brunt from the flood waters must be on the right bank and this side always needs the greatest possible care.

(c) Tendency for an avulsion or cut-off in the region of the Sukkur-Begari Bund. There is a tremendous loop or meander of the river round Chak, Sukkur, and Ruk, - the largest in the whole course of the Indus in Sind. If this section of the river embankments is not properly treated, sooner or later an avulsion may take place; that is to say, the river may rush directly from Chak to Ruk and the Sukkur Barrage may be bypassed! The Sukkur Barrage is the very heart of Sind and in the right place. Sind will have to pay a far heavier price than any of its periodic flood calamity, if a cut-off really and actually takes place.

(d) Rise of level in the Indus valley. Students of geography are aware that the bed of the Indus has been rising steadily ever since the formation of its delta in its mature age. This is due to alluviation and deposition of silt etc., in the aggraded parts of the valley. This level has been calculated to be nearly one foot per century; but the Punjab engineers, notably Mr. Foy, has given the rate over 19 feet per century in the Punjab. Evidently, therefore, the embankments or *Bunds* have to go higher and higher and higher still day by day, unless more and mare canalization is done all over the valley. Today the bed of the Indus itself is nearly 50 feet higher than the surrounding Country, which is therefore naturally flooded whenever the level rises.

(e) Effects of earth movements. Sind is definitely within the danger zone of the earth, - witness the Quetta earth-quake. Every tremor of the earth affects river channels and engineering works in such an unstable region.

(f) Bursting of glacial and other dams across the Shyok and

other tributaries of the Indus in the Himalayas.

(g) Unusual rains and snow-falls. As stated earlier, a vague cycle of six or seven years has been noticed in the rainfall curve of Sind. Provision has then to be made for an unprecedented rainfall in the whole of the Indus basin including the catchment areas of all its tributaries. All the Punjab rivers empty themselves into the Indus. It is not easy to forecast the rainfall in all the different catchments every time. At times the floods come from the S. W. monsoon and at other times from the western depressions or winter rains. In the critical months of April, May and June when the plains are parching and the sun melts the snows in the higher reaches, an extraordinay flood arrives. Kanwar Sain while giving the discharge measurements of the Punjab rivers for different months in his 'Hydrology of the Punjab Rivers', states that they vary widely even for the same months from year to year. While, for instance, the maximum discharge of the Indus in March is only 70,000 cusecs, it increases to 112,360 in April, to 240,000 in May, 338,000 in June and nearly 560,000 in July. Provision has to be made for such extraordinary discharges, while running engineering works during July-August. A constant watch has besides to be kept on the role and measurements of glaciers and snowfall.

(h) Lack of Regional Surveys. Lastly the maladies of Sind and Pakistan in the matter of flood visitations have to be investigated and treated regionally and not piece-meal.

Remedies: At the risk of a boring repetition, the following remedies need must be suggested to avoid future troubles in Sind:

1. Strengthening the most delicate parts of the Sukkur-Begari Bund— mere earth embankments will not do in the Chak-Sukkur-Ruk loop at least.

2. Providing for shock absorbers or reservoirs for absorbing overflow water above the Bukkur gorge. There are some low-

lying areas on the right bank of the Indus in the Sukkur district as waste lands, which would be very useful for flushing the Indus in floods.

3. Assisting the Indus in its "tendency to short-circuit" by cutting a channel directly from Chak to Ruk or even making a special canal, which would not be longer than 16 miles.

4. Stabilising the main channel of the Indus. Strict watch has to be kept on the rise and fall of the flood levels, the tendency to erosion, and corrosion and corrasion, of the banks and bed of the river, etc.

5. Forecasting floods and developing a technique of river control to be unsurpassed by any in other parts of the w orld.

6. Specialising the courses of engineering studies in the national Universities with a postgraduate diplomas to be awarded for river researches.

It must be remembered that the havoc wrought by floods is not peculiar to Sind alone. Even West Punjab is liable to such destructive inundations. Only in July, 1948, some 250 villages were washed away in Muzaffargarh District and the rushing waters took all the inhabitants unawares. Several railway lines and roads were damaged. These were due to floods in the Chenab river, - and the Chenab is a very important tributary of our classic river Indus. Both West Punjab and Sind are vital parts of Pakistan and this leads us to the question of seeking the wealth and welfare of the whole dominion of Pakistan in matters scientific and not political.

Our thoughts in this regard, naturally go to those selfless workers in the field of science, who conceived the various profitable schemes of irrigation and agriculture in Sind. They were able to control nature to a certain extent and have made Sind now quite independent of the monsoon. This is a great achievement of man in the province. The story of the Sind floods is the eternal story of the struggle of man against nature,

and man must win in the end.

"From the report of the Natives, it appears that a very high inundation sometimes occurs in Sind, which invariably causes great alterations in the lower part of the Indus; it is said to happen once in about half a century. About eighteen years ago (1819?) one of these floods came down the river, rose to several feet above its usual height during the swell and the strength of the current was much greater than in many parts of the country. The crops were completely destroyed. On this occasion, the river altered so much about the part where the Setta was thrown off, that a larger body of water than usual was forced into that stream, and it increased in size considerably. The change became greater every successive year, until at last the main river turned into the Setta and abandoned the Buggaur altogether."

3. *Silt carried off Keamari:* The force of the S. W. monsoon wind is very great on the coast, so much so that the silt brought down by the river and dropped off its mouths, is carried far and wide. The mineral character of the muds off Keamari examined by Tremenheere appeared to him to be akin to that of the silt carried by the Indus as has been already noticed. They contained quartz and mica in a finely divided state and appeared to have been brought near the harbour by the influence of the S.W. monsoon current on the sea waters. Recent microscopic examination of Keamari mud has confirmed this.

4. *Nature of River Banks :* The banks gradually grow steeper as we move upwards reaching a height of about 15 feet but in the lower part of the Delta there are low banks. In places they stand steep and wall-like.

5. *Best Bridged River :* Owing to its peculiarities, irregularities and alluvium, old and new, the River Indus has come to be exceptionally and peculiarly bridged, e.g., between Leh and Kotri, it possesses all sorts of bridges including boat-bridges.

The position and construction of the Landsdown Bridge of Sukkur is a triumph of the art of bridge-building. There being little space between the Bukkur island and Sukkur, a cantilever bridge was the only possibility. The Barrage with as many as 66 spans is a marvel of civil engineering. Another important bridge is at Kotri, crossing the mud banks of the river, and at the old port or *Bunder* of the Indus Flotilla, called Gidu.

COMPARISON WITH THE NILE

In his discussion about the variation of the Nile flood, Captain H. G. Lyons suggested certain meteorological conditions extending over large areas in Asia and Africa and affecting the rainfall and floods of the Nile. The variations of atmospheric pressure and of the maximum and minimum sunspots have something to do with it, but observations of these conditions do not guarantee any production of high or low flood pulses.

His conclusions are:

1. Generally speaking, the curve of Nile floods varies inversely as the mean barometric pressure of the summer months; high pressure accompanies low floods, and low pressure accompanies high floods.

2. These pressure variations show a great similarity over wide areas, but seem to be to some extent dependent upon the position of the Azores high pressure 'action centre'.

3. Taking the monthly means of atmospheric pressure, this relation is even more clearly shown above or below the normal in months of the rainy season of Abyssinia, coinciding closely with the deficiency or excess of rainfall.

4. Taking the 37 years (1869-1905): in 6 years out of 7 a very fairly accurate prediction of the flood from month to month could have been made, and there seems a reasonable probability that further and more detailed study of the conditions above described may increase the reliability.

5. The effect of excessive sub-equatorial rainfall in April and

May in the neighbourhood of Zanzibar seems to have a distinctly prejudicial effect on Abyssinian rains.

In the same way, it is possible that whenever there is a diversion of S. W. monsoon current from the west and north-west India to either Abyssinia or Burma, there is a likelihood of general or local scarcity of rainfall in the region. At the same time a weakness of the wind currents in one area may also be felt in areas in similar latitudes, as the tropical rainfall of all these localities is caused "primarily by the transfer northward of the equatorial rain-belt followed by the northward extension of the southeast trade winds".

As we have noticed above, mere meteorological conditions over the Indo-Gangetic plain do not affect the Indus floods in a particular year; melting snow makes a lot of difference in the discharge. There are other material differences also to be noticed between these two great rivers :-

The Indus	*The Nile*
1. An antecedent river flowing across the Himalayas and a consequent channel through a synclinorium from north to south.	1. A consequent river now flowing through a rift valley near the sources from south to north.
2. Sources of water-supply unsteady: (i) Glaciers (snow melting in summer months), (ii) Numerous affluents, (iii) Seasonal monsoon rains (S. W. and N.E.).	2. Constant water-supply: Equatorial rains (March and Sept.) only. No snows. Seasonal rainfall(monsoon)-on Abyssinian highlands(July-August).
3. Variable channels.	3. Comparatively constant channels.
4. Considerable fall - 11,000 ft. at Gilgit.	4. Less fall from heights.
5. Light friable shifting soils & fine sand banks, shallow and shifting torrents.	5. Rocky parts in upper region. Argillaceous soil, deep bed, uniform flow and rapids and cataracts, in lower region.
6. A Barrage at Sukkur.	6. A Dam at Assau.
7. No lake regulation and hence disastrous floods in season.	7. Lake Victoria serving as a reservoir. No irregular floods.

8. No tributary in Sind (Lower valley).	8. Tributaries of the Blue Nile and the Atbara in Egypt.
9. Navigation : Only in flood seasons, though difficult due to sand banks; small native boats sail, flat-bottomed and light, drawing 3' of water merely.	9. Navigable in all season and times: Large boats meant for sea voyage and shore-going craft used.
10. Colour of water : muddy but capable of filtration.	10. Blue to red due to Fe 2°3 in suspension.
11. Ever changing and growing delta and mouths of the river.	11. Better delta.
12. No great or old towns, ports; not yet a well cultivated valley.	12. Large old towns exist. Richly cultivated valley.
13. Present average advance of delta: 4 yards per year.	13. 4½ yards per year.
14. Climate: Extremes of heat and cold. Scanty rainfall.	14. Hot and cold seasons. Good seasonal rainfall.
15. One of the best bridged rivers in the world.	15. Not so well bridged.

SUMMARY OF STATISTICS

Total length of the River course from source to mouth:	1,800	miles
Length of the River in Sind (with windings)	580	miles
Drainage area of basin	372,700	sq. miles
Total area of Lower Indus Basin (Sind)	52,944	sq. miles
Discharge (average of 29 years) at Sukkur	5,086,270	mln. c. ft.
-do- -do- -do- Kotri	4,293,672	mln. c. ft.
Discharge (minimum)	17568,	cusecs
Discharge (Maximum)	885165	cusecs
Highest rise of water level (1929) at Sukkur	17.70	feet
-do- -do- -do- Kotri	24.10	,,
Silt carried (average for 29 years) at Sukkur	9,937	mln. c. ft.
-do- -do- -do- Kotri	8,299	mln. c. ft.

Average inclination of the plain	9″	per mile
Maximum velocity per second	10.61	feet
Silt carried	1,000,000	tons a day
Depth of the stream in the delta	1 to 4½	fathoms
-do- -do- higher up	1 to 6	,,
Total length of the irrigation canals "branches" tributaries	6,211	miles
Length of the longest canal (Rohri) in the Indus system	208	miles
Total command under all canals	7½	mln. acres

Recent Data of Hydrology of the Indus : Data supplied by the Secretary, Indus River Commission, Karachi.

Statement showing the quantity of water and total volume of silt passed down the Indus (Annual) (Sukkur and Kotri).

Year	River discharge in million cubic ft.	Silt in million cubic ft.	River discharge in million cubic ft.	Silt in million cubic ft.
1930-31	4007158	6656	3614002	6737
1931-32	3910983	6028	3390438	5960
1932-33	5025487	9090	4112596	8351
1933-34	4255784	7739	3487117	6585
1934-35	3143633	3698	3330615	4894
1935-36	5021003	8786	3924493	7620
1936-37	4201279	5958	3280410	4982
1937-38	4834615	7756	3884256	6836
1938-39	4611156	6301	3555006	6554

Note:- From 1940 todate, the data are not available.

Statement showing the Minimum and Maximum Gauges recorded at Bukkur during each year from 1932 to 1952.

	Minimum		Maximum		R.L. of Zero of	Remarks
Year	Date	Gauge	Date	Gauge	Gauge	
1932	12.3	0.20	11.8	16.70	184.44	Minimum gauge reading occurs in December-January, and maximum in August.
1933	22.12	1.20	11.8	16.30	,,	
1934	25.12	2.80	16.7	14.10	,,	
1935	23.3	2.90	23.8	15.00	,,	
1936	18.12	0.10	28.8	13.00	,,	
1937	27.12	0.40	6.8	13.80	,,	
1938	28.12	1.70	24.8	16.00	,,	
1939	29.12	1.30	6.8	15.80	,,	
1940	5.1	1.10	17.8	15.10	,,	
1941	5.1	0.90	14.8	14.80	,,	
1942	9.1	2.00	22.7	18.20	,,	
1943	3.1	2.30	14.8	20.20	,,	
1944	8.1	2.50	19.8	20.20	,,	
1945	31.12	0.60	4.8	19.50	,,	
1946	6.1	0.40	24.8	18.40	,,	
1947	1.1	1.80	17.8	15.10	,,	
1948	1.1	1.90	25.8	20.60	,,	
1949	31.12	0.90	6.8	18.60	,,	
1950	13.1	0.50	10.8	18.00	,,	
1951	11.1	0.30	20.8	14.80	,,	
1952	26.12	0.20	3.7	15.20	,,	

Statement showing the Minimum and Maximum Gauge recorded at Kotri during each year from 1931 to 1952.

	Minimum		Maximum		R.L. of Zero of Gauge	Remarks
Year	Date	Gauge	Date	Gauge		
1931	13.3	5.46	4.9	19.23	42.90	Minimum gauge reading occurs in March, and Maximum in August
1932	31.1	4.40	19.8	23.70	,,	
1933	18.3	1.45	6.9	24.90	,,	
1934	9.3	0.15	3.8	22.60	,,	
1935	28.1	0.80	30.8	23.50	,,	
1936	3.3	0.40	18.7	20.40	,,	
1937	14.2	4.50	10.8	20.30	,,	
1938	30.1	4.00	29.8	21.80	,,	
1939	25.2	3.30	11.8	21.10	,,	
1940	4.4	1.00	21.8	20.30	,,	
1941	25.3	1.30	1.9	18.80	,,	
1942	18.2	3.70	10.9	23.50	,,	
1943	15.3	1.70	22.8	24.30	,,	
1944	12.2	2.53	29.8	25.10	,,	
1945	18.3	0.40	13.8	22.00	,,	
1946	2.4	2.40	20.8	21.40	,,	
1947	20.3	0.60	7.9	18.00	,,	
1948	15.3	0.10	31.8	30.00	,,	
1949	11.3	2.80	19.8	23.80	,,	
1950	29.3	2.40	19.8	24.90	,,	
1951	16.3	1.10	27.8	19.90	,,	
1952	24.3	1.10	25.8	22.00	,,	

Statement showing the Minimum and Maximum discharges at Panjnad during each year from 1931-53.

PANJNAD

Year	Date	Minimum Discharge	Date	Discharge Maximum
1931	19.12	940	29.8	306052
1932	14.10	168	6.8	249304
1933	7.3	1643	26.8	333759
1934	12.3	146	21.8	246676
1935	16.3	426	19.8	309244
1936	8.2	239	11.7	244478
1937	30.10	96	1.8	163944
1938	29.10	125	21.8	246238
1939	17.12	99	30.7	197380
1940	30.3	46	15.8	215472
1941	24.3	79	28.8	136822
1942	12.11	104	30.8	430000
1943	13.11	78	11.8	316962
1944	29.10	57	18.8	273000
1945	16.11	50	31.7	254063
1946	1.11	34	30.7	228144
1947	24.2	100	4.9	198298
1948	15.11	107	21.8	481134
1949	17.12	184	6.8	304976
1950	8.1	149	27.9	676722
1951	6.1	120	17.8	237570
1952	20.12	81	12.8	306732
1953	26.3	30	—	—

The lowest maximum discharge was 1,36,000 cusecs in 1941 while the highest maximum was 6,76,000 cusecs in 1950.

Statement showing the Minimum and Maximum discharges at Sukkur during each year from 1931-53.

SUKKUR

Year	Date	Minimum Discharge	Date	Maximum Discharge
1931	5.3	27550	31.7	446606
1932	11.2	11838	8.8	571986
1933	4.2	10361	31.8	627454
1934	1.4	4934	15.7	584945
1935	31.1	27279	23.8	672901
1936	1.3	21170	15.7	499621
1937	1.1	21812	7.8	434664
1938	12.1	21410	3.8	519092
1939	18.2	22935	5.8	485187
1940	27.3	20566	17.8	457539
1941	2.4	18351	30.8	407207
1942	7.1	29630	22.7	573569
1943	8.3	26050	14.8	727919
1944	27.2	24229	23.8	694328
1945	28.2	24187	7.8	663178
1946	7.1	16116	24.8	503580
1947	7.1	14532	3.9	358578
1948	23.1	18521	24.8	760397
1949	1.2	24693	10.8	655237
1950	15.1	17291	11.8	775522
1951	13.1	11179	20.8	483202
1952	7.1	4052	27.7	594279
1953	7.1	7402	—	—

The lowest maximum discharge was 3,58,000 cusecs in 1947, while the highest maximum discharge was 7,75,000 cusecs in 1950.

Statement showing the Minimum and Maximum Discharges at Kotri during each year from 1931-1953.

KOTRI

Year	Date	Minimum Discharge	Date	Maximum Discharge
1931	14.3	25435	1.8	372579
1932	16.2	17732	18.8	501079
1933	17.3	4375	6.9	608087
1934	9.3	4858	9.8	496585
1935	25.1	8604	30.8	481481
1936	29.2	4199	18.7	372360
1937	7.2	11647	10.8	389209
1938	28.1	10054	12.8	435200
1939	24.2	3929	9.8	396325
1940	5.4	1944	20.8	349083
1941	27.3	1405	31.8	323704
1942	18.2	7478	10.9	529252
1943	13.3	7875	21.8	554653
1944	29.2	5341	23.8	604281
1945	18.3	3480	13.8	535167
1946	9.3	3415	26.8	421131
1947	22.3	2115	7.9	291804
1948	15.3	1601	30.8	714713
1949	11.2	5827	19.8	621965
1950	4.2	4723	19.8	663038
1951	25.3	3029	27.8	334456
1952	25.3	2074	25.8	482539
1953	4.4	1611	—	—

The lowest maximum discharge was 3,23,000 cusecs in 1941 while the higest maximum was 7,14,000 in 1948

Statement showing Monthly Average at Mithon Kot from 1931-1953

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1931	30227	34920	34584	60195	115696	94058	...	...	11712	92779	48293	36413
1932	34007	31348	45004	63932	81546	...	...	...	...	61289	35177	28107
1933	25382	23903	30641	60562	93945	...	...	...	...	97405	45311	38701
1934	29044	24832	25680	38357	53861	35355	...	...	...	61309	38219	32161
1935	29028	46122	38173	100133	92070	...	...	...	...	59437	39461	13785
1936	29065	24091	78676	90496	94894	...	...	...	...	33877	43309	36599
1937	32250	32862	50804	51076	...	...	...	...	...	30898	37423	30917
1938	31430	42444	49363	108306	55079	...	...	...	...	33625	36052	31064
1939	26653	27806	81625	135600	42047	...	...	...	...	58797	37531	29695
1940	19447	26932	23730	48782	86063	...	...	...	...	40973	31972	27676
1941	24430	22753	22576	45020	60422	...	...	...	...	64727	36842	31793
1942	40565	53375	75619	111611	20721	...	...	...	...	37067	40986	33909
1943	49500	40384	45417	84876	92251	...	...	...	...	50120	38511	30795
1944	27880	25414	37729	96163	9960	...	...	...	...	51207	35880	29558
1945	35863	26616	30335	81887	70650	...	...	...	...	47127	41700	31513
1946	26859	26097	28497	56952	45847	...	...	...	30824	60891	35754	27213
1947	28505	25633	22375	40369	44225	...	...	...	...	24534	35418	26126
1948	26787	22456	43655	90046	...	...	...	...	87448	78157	35825	29839
1949	29886	39673	50275	10557	...	...	...	...	...	46123	36145	30030
1950	28947	60363	13999	82171	57746	...	...	...	...	27778	50679	35272
1951	30638	28904	34993	59638	44968	...	...	...	...	54868	33255	28640
1952	26641	25465	27904	58201	38276	...	...	...	...	56003	33385	26879
1953	26129	24852	21035	49291	...	...	...	...	...	...	...	...

(... Discharge observation closed due to high abkalani.)

Statement Showing Monthly Average At Kotri From 1931—1953.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1931	29596	32279	30610	40066	96308	134323	254078	326731	262110	88592	48462	33355
1932	27935	23687	29574	39420	49934	146745	199563	420750	188818	59354	23217	14289
1933	11426	13987	9756	42695	51541	169559	314765	471351	358357	120850	31168	23864
1934	12708	8495	12986	18954	26614	115797	286506	444323	167219	51805	21211	23258
1935	12424	19558	28323	65735	86186	142981	249681	426580	137506	44649	22850	24452
1936	11836	7938	53811	56859	116230	289914	301604	314273	229566	58339	26960	26134
1937	19168	13857	24859	47711	113032	181528	266662	299430	178564	36158	18327	21842
1938	14714	13456	20374	64557	167486	306811	254437	383089	172337	32749	17881	19692
1939	11689	5012	45228	93563	134193	208371	270712	299794	200060	51608	20955	15416
1940	17096	4986	3164	15271	41196	159373	248532	302307	112739	22985	14519	10491
1941	13820	2595	1788	9019	86848	187155	235254	240670	160010	40044	19385	14677
1942	27950	13915	46618	72323	127685	127938	290667	423593	384851	96873	40079	26826
1943	42726	21376	16585	51612	59289	166115	271649	472762	302106	67608	23342	16442
1944	20145	6221	14365	53317	86008	103496	223068	478035	252988	47599	23993	16810
1945	21882	13945	7335	55385	80584	140133	36508	405758	242961	94350	26027	18170
1946	18466	5477	6359	16440	101344	101590	201014	368325	152658	37101	18972	11466
1947	18396	4224	2923	10086	30700	150474	149360	214828	232936	121233	21333	11278
1948	16760	2971	53110	47701	122880	104107	198700	510704	366380	66561	28030	14972
1949	24469	12048	21861	62491	166368	135438	276521	477131	148912	60900	21428	12422
1950	18779	27400	12041	51116	107894	221929	396151	563629	342889	17276	33382	19293
1951	23490	6255	6257	32417	37017	149910	169163	263376	123642	34190	14795	9539
1952	17213	3828	2295	17562	67310	156571	314798	429341	145728	38915	13078	7444
1953	15688	3305	2047	13275	72895	127626	—	—				

CHAPTER IV

CLIMATIC CONDITIONS

INTRODUCTION

Parts of the Indo-Pakistan subcontinent form some of the warmest regions of the earth. In this tropical region with a climate of great diversity and range, Sind is found to be the driest and hottest of all its provinces, the distribution of solar radiation playing a prominent part in this. Aridity is its main characteristic, with Jacobabad (mean maximum temperature 113° F. and mean humidity 41 per cent) as the hottest and driest place in the subcontinent. The tropic of Cancer passes a little below its southern boundary and so the solar heat is great, coupled with longer hours of sunshine in the hot season. The climate is reminiscent of the 'sahara' type, and of that prevailing in hot and dry lowlands. It presents a great contrast with Assam at the other end of the subcontinent in regard to humidity—a contrast greater than that between Egypt and the British Isles. It is rather cold in winter for the latitudes within which it falls (viz., 23° 35' and 28° 30' N) parts of it being colder than the Punjab situated higher up and encompassed between latitudes 29°-31° N.

The thermal equator (the line of the greatest mean heat of the globe) passes through Sind. "It has long been known that what is termed, the thermal equator, does not follow the course of the equinoctial line, where, on the average of the year, the sun's action is most direct and intense, but in the longitude of India bends northwards, running up through Ceylon and the peninsula to beyond the tropic and passing through Sind, crosses thence to the Arabian peninsula."

In the matter of rainfall, another important factor of climate, the region also suffers greatly. It is said to be 'between the two monsoons', known as the S.W. and N.E. It misses the influence of the former, while the latter does not extend much beyond the Ganges basin. The average rainfall in the valley is meagre and precarious. Contrast with this the region of Western Deccan, which receives almost the whole of its annual rainfall in summer and in abundance, and the North West Frontier-Province with its main share of rains in winter. The mountains on the west of Sind are not sufficiently high to catch the S. W. monsoon currents in one part of the year or to prevent the cold blasts from the Iranian Plateau from entering the region in the other.

Thus the chief features which affect the climate of Sind are:

(i) The tropical zone in its southern half and the temperate zone in its northern one.

(ii) The position and direction of mountains, e.g. the Himalayas which prevent the northern cold and induce the southern rains.

(iii) The Thar Desert Region in the neighbourhood.

(iv) Nearness or remoteness from the Arabian Sea.

(v) Presence or absence of forests.

Within the region of Sind there are marked climatic contrasts; there is an uneven distribution of rainfall from one end of it to another. Jacobabad has an average rainfall of 3 inches, while Nagar Parkar has 15 inches. Ordinarily there is almost no rainfall in some parts of the desert area, but in years of heavy downpour a whole season's rainfall is received at some places in Sind in a couple of days, it being as heavy as 3 inches per hour, e.g. on 17th. June 1952, when 7 inches of rainfall were recorded at Karachi. Places nearer the sea get somewhat better and regular rains. The diurnal and seasonal variations of tem-

perature are great in many parts of Sind. The thermometer drops below freezing point in winter with frequent cold spells and frost in North Sind; while heat waves with whirlwinds and dust storms are common in summer throughout the Province. There are no great forests in Sind to render the rainfall more effective except in a few narrow strips along the river banks. Dry land winds blow most of the year. 'It is this persistence of land winds which explains the aridity of the Indus Valley; for, the south-west direction, that prevails in the Valley itself, is merely that which is given to the current by the trend of the hills that bound it'. This dry wind system prevails over the greater part of the Province, except near the coast, where the influence of the monsoon winds is felt somewhat. But the chief causes of this drought in Sind are the deficient relief of land and the very high temperatures and low humidities, jointly operating to reduce the chances of rain or even of cloud formation. On the whole, the climate of Sind can be called a Desert climate —a cold dry winter alternating with a hot summer, with very meagre and precarious rainfall.

GENERAL CLIMATIC CONDITIONS OF THE INDO-PAKISTAN SUBCONTINENT AFFECTING SIND

A. *The Monsoon:* The Indo-Pakistan subcontinent is one of the monsoon lands of Asia. The word 'Monsoon' is derived from the Arabic *mausim*, season or seasonal wind, the wind direction being the chief factor in the pratice of navigation of those days. This wind depends upon the principle that it always blows from places which have greater barometric pressure to those which have less. This wind pressure gradient in its turn, depends upon the rate of heating and cooling between land and sea.

The very nature of the peninsular projection of the subcontinent into the Indian Ocean helps this. During the m6nths of March, April and May, the sun's rays fall almost perpendicularly on Northern India and the barometric pressure in this region

is lowest, while over the Indian Ocean and lower down, the air is comparatively cool and the pressure high. A flow of air is consequently generated inland from the seas, and crossing them for nearly 4,000 miles, it is charged with considerable moisture. Also the hotter the air, the more moisture it carries in an invisible form. This current of air does not flow directly from south to north. As a result of the rotation of the earth, air currents in the Northern Hemisphere circulate anti-clockwise,—hence the S.E. trade winds, which on crossing the equator are caught in the circulation around the low pressure system existing over the N.W. corner of Pakistan and Sind, and move, over the region of the Arabian Sea on one side and the Bay of Bengal on the other, deflected as the S.W. Monsoon, according to Ferrel's law. At the equator, due to the rotation of the earth, but as it goes up to higher latitudes, it reaches the air currents which move slower and hence overtakes them, deflecting itself eastwards.

Over Sind, there is in summer a persistent depression with an oval isobar of only 29 inches round about Jacobabad, and an isotherm of about 100° F. co-terminous with it. There is, therefore, a difference of nearly an inch of barometric pressure between South India and this region, which at once becomes a theatre of great atmospheric depression, breeding thunder-storms and air disturbances. In this respect the contribution of Sind to the whole subcontinent and its rainfall is very great.

On entering India, this moisture is precipitated as the air advances northwards over the country, because the general pressure distribution over Asia and the Indian Ocean forces it into this box or *cul de sac*, out of which it can only find a way by rising over the sides.

Causes of Precipitation : Although the chief cause of the rainy season is this pressure distribution over land and sea, actual precipitation results from several other circumstances. The

orographical structure of the whole country is mainly responsible. At the very outset, the Western Ghats obstruct the path of the monsoon. This obstruction is beneficial since the air currents are forced to a height of nearly 5,000 ft. and the vapour is condensed. As the currents blow across the country, they find no openings in the north, north-west and north-east which are blocked by the extra-peninsular mountain ranges of insurmountable heights: therefore, they must rise higher and higher. This ascensional movement, thousands of feet above sea-level, causes complete condensation and rainfall for the country.

Branches of the S.W. Monsoon: It should be noted that these ascensional movements flow in two different directions: (1) Those flowing over the Arabian Sea crossing the Ghats and penetrating the Narbada and Tapti Valleys, called the Arabian Sea branch, and (2) Those blowing from the Bay of Bengal along the Burmese Yomas and the Assam Hills, called the Bay of Bengal branch of the summer monsoon As the Bay current is checked by the Himalayan barrier, it bends westwards as the S.E. monsoon and passing up the Gangetic Valley, it reaches the eastern limits of the Punjab in a very weak state.

Those parts of the subcontinent which do not lie within the paths and ranges of these two S.W. and S.E. monsoon currents - those which lie in the rain shadow areas, and those which have low or no mountain barriers, receive scanty rainfall in this season. Thus Mahabaleshwar, 4,500 ft. on windward side of the Western Ghats, receives an average rainfall of 300 inches; Poona and Bangalore on the leeward side of the Western Ghats receive only 25 and 10 inches respectively; while Peshawar in the extreme N.W. gets less than 15 inches and Jacobabad in Sind less than 5 inches. Most of Sind lies outside the path of the S.W. monsoon and it has no high mountain barriers to catch it. The other branch of the summer monsoon, viz., the Bay current, giving as much as 500 inches (average) to the Assam Hills (Cherra Punjee), does not reach parts of Sind and the Punjab. The

currents get weaker and weaker as they travel further westward: thus Peshawar gets only 4½ inches and Sukkur 2 inches during the whole summer season. Even the cyclones developed in the Bay of Bengal during the monsoon period, do not usually travel as far as the Indus basin.

This wet season lasts for about four months from June to September, at the end of which period the moisture is exhausted and the currents become greatly weakened. As a rule, nearly three-fourths of the total annual rainfall of the subcontinent is caused by these monsoon currents.

N. E. Monsoon: By the end of September, the meteorological conditions of the subcontinent are reversed. The rays of the sun are also aslant in these months. While the S.W. monsoon is still hanging over the country, particularly over Bengal, the air over the greater part of Central Asia becomes cold and an anticyclone, exceeding, 31 inches and resting on Tartary, is developed. North of this region, the barometric pressure slopes away to the Arctic Ocean, and south of it falls to the equator, thus causing the Central Asiatic anticyclone to persist for some time.

Because of these changed conditions, the S. W. monsoon current still flowing into the Bay of Bengal, cannot enter this high presure region and retreats round the area of low presure in South India, as "the retreating monsoon". This is also called the N. E. monsoon. "After September, the region of chief indraught gradually travels southwards, far in a northerly direction. Accordingly, in October pressure in the Bay of Bengal is in general the lowest in the area lying off the Madras Coast; and from this time onwards, rain occurs in the Peninsula chiefly in connection with a series of depressions or areas of low pressure, which form in the Bay of Bengal and strike the coast. The rain-bearing winds at such times are north-easterly and hence the rains of the N. E. monsoon." This current does

not affect Sind. It is gradually exhausted in its passage westwards and there is a break in the rains for about a month or so, viz., October.

Winter Rains in Northern India: By November-December the temperature at Jacobabad falls as low as 50° F and though the pressure gradient is also low, steady winds begin to blow from the N. W. These are mainly continental winds and therefore, dry. But where they pass, they are condensed and precipitated by the northern winds. Thus we have snows on the Himalayas and winter rains in Northern India.

It should be borne in mind that the belt of high pressure and the anti-cyclonic conditions in winter are not local but stretch over a wide area of varying physical features from the Mediterranean to Central Asia as far as N. E. China, corresponding to the belts of high latitudes in the Atlantic and Pacific Oceans. As a result of this, shallow or feeble storms pass successively across Central Asia, and occasional showers of rain are the predominant weather conditions in winter in the Indus basin.

B. *Other External Causes:* Apart from the regular monsoon currents, such cyclonic storms or dirturbances as cross the whole region are a very important feature of the climate of Sind. Dr. B. N. Banerjee has classified the meteorological conditions prevailing over the section of the Persian Gulf to Karachi, under two distinct types, the winter and the summer, western depressions and eastern depressions respectively. These storms differ from the regular cyclones, which are winds of great destructive violence but do not bear much rain. The cyclonic storms, though milder, are very extensive and bring about winter rains in Northern India. The difference of barometric pressure gradient too is very small, e.g., about 3/10th″ of an inch. "Also they are more lasting than the cyclones, and at times bring torrential rains. They travel over hills without any loss of energy, unlike cyclones which are dissipated by mountains."

Thus floods are caused when a shallow low disturbance is superimposed on the general regional flow. It has been noticed that the Makran Coast from Gvadar to Karachi is disturbed more by summer weather storms than by winter ones while in the interior of Sind and the Punjab it is the western (winter) disturbances which are more important.

Winter Conditions: Western Depressions : From December to February depressions originate as far as the Atlantic Ocean and the Mediterranean Sea and periodically pass through the region of high pressure or the anticyclone belt created in Central Asia in the cold season. Whenever they pass over masses of water, e.g., the Persian Gulf, they collect moisture which is ultimately precipitated as rain elsewhere. There are original or parent depressions, which are formed at the meeting place of the polar and the equatorial air, and depending upon the "juxta-position of two different air masses, having different characteristic properties, such as temperature and humidity". Then there are secondary depressions, which are formed generally "when the members of the family are moving over hilly regions or are nearing the end of their activity", and which having been thus formed, behave like other western depressions. These depressions generally move north-westwards along a big front - "older members dying out at one end and new ones appearing at the other".

The nature of such a western disturbance is three-fold, that is to say, there are three distinct weather conditions, following one another, as it moves onwards: (1) The warm front stage, whereby an air, mass warmer and more humid, moves forward and there is a sudden change of wind direction with rise of temperature and cloudy air accompanied by squally weather with passing clouds and drizzles or fog. (2) The warm sector stage, by which fine weather becomes settled down but with very high temperature and humidity. It is the steamhouse of the depression. (3) The cold front stage, whereby a mass of

cold air enters the area and there is a sharp change of wind direction with a rise of barometric pressure, reduced humidity and sharp convectional currents. The result is squalls, thunderstorms, dust-storms and showers of rain.

These western depressions generally occur several times during a winter month and depend for their intensity upon the degree of contrast existing between the two air masses mentioned above.

Only a portion of these cyclonic storms and disturbances affects the Indus basin and Sind. On reaching Makran, they generally split themselves into three streams covering (1) The Western Highlands, (2) The Punjab and Kashmir, and (3) Sind. The last stream is feeble and so gives little rainfall in the region of our study. On crossing the Kirthar Range the storms usually develop secondary depressions which also create disturbed weather in Sind.

Summer Weather and Eastern Depressions: From June to August, the low pressure area extends from N. W. India to Iran and Arabia, and depressions arising in the Bay of Bengal or the Arabian Sea and moving across Central India pass through this low pressure region. Like the western disturbances these storms are also caused by the monsoon winds and the N.E. winds from the Bay. Some times they die out when over Central India, but at other times fresh depressions arise from them over Rajputana—'at the meeting place of the fresh Arabian Sea monsoon air and the land air which is the old modified air from the Bay'. Whenever such a secondary depression travels westwards with fresh vigour, there is a chance for Sind to get rains. 'There, eastern depressions, when they are over N. W. India, induce an inflow of the Arabian Sea monsoon current, which, because of its moisture content, maintains the activity of the depressions, whereby cloudy weather storm winds and rainfall occur in Sind'.

Also, while moving further towards the west into the Arabian

Sea off Makran, such depressions cause rough seas and squally weather over the Pasni-Karachi section.

Transition Periods: Between these two distinct periods of winter and summer depressions, i.e., between September and November and between March and May, which are called transition periods, the characteristics of both depressions are noticed: not extensive storms, but only localised weather disturbances without any regular sequence of phenomena. Thus feeble or strong, local or wide-spread disturbances of weather are likely to occur in Sind throughout the year.

Cold and Heat Waves: The passage of cold and heat waves through our province can be easily understood since the foreign disturbances described above are their cause. As they pass over Sind, the weather invariably becomes abnormal, i.e., abnormally hot at one time and abnormally cool at another. These waves are the distinct triple weather conditions noticed above in connection with the depressions and disturbances. Such weather spells are frequent in the winter months, e.g. about half a dozen in January. They have a mass of warm air in their southern and eastern quadrants, and cool air in their northern and western quadrants. As soon as they approach a station, there is a rise in temperature which then drops to several degrees below normal, when the depression has passed away. The weather remains abnormal, until another depression from the west approaches. Side by side with these disturbances there is good rainfall or snowfall in the localities crossed by them. At times they travel eastwards as far as Bengal, Burma and Assam and even beyond, if they are strong enough.

One or two examples of such waves may be cited here: In January, 1935, a western disturbance passed over the Gulf of Oman, the Punjab, the United and the Central Provinces causing snow or rainfall in all these areas. The depression was followed by cold waves, which affected Makran and Sind, Nawabshah recording the lowest temperature, of 27° F., while

at other stations in Sind freezing point was passed.

The following minimum temperatures were recorded at Manora and Drigh Road, though the disturbance did not directly affect the two localities.

January 1935	Manora	Drigh Road	Fall of Temperature.
12th.	55° F.	51° F.	
13th.	48° F.	40° F.	10° to 12° F.
14th.	47° F.	37° F.	

Notice the great difference also between the temperature of the two places, viz., as much as 10° F., though they are only 10 miles distant.

There was another instance of a heat wave, followed by a sudden drop in the temperatures, recorded at Drigh Road, during the same winter season, viz., on the 12th. November, 1934.

Hour	11th. Nov.	12th. Nov.	Fall of T.
9-15 a.m.	79° F.	75° F.	4° F.
10 a.m.	85° F.	79° F.	6° F.
11 a.m.	91° F.	83° F.	8° F.
12 a.m.	94° F.	85° F.	9° F.
1 p.m.	96° F.	86° F.	10° F.
2 p.m.	98° F.	86° F.	12° F.
3-45 p.m.	98° F.	86° F.	12° F.

Similarly, spells of heat in summer months are also usual: e.g.

May 1937	Manora		Drigh road		Departure from the Normal
	Max. T.	Min. T.	Max. T.	Min. T	
16th.	89° F.	80° F.	91° F.	80° F.	

17th.	87° F.	79° F.	102° F.	81° F.	5° to 10° F.
18th.	94.6° F.	80° F.	111° F.	81° F.	

Such instances can be easily multiplied, the weather conditions of places under the disturbance being invariably abnormal; for instance, temperatures in the Nawabshah District are very uneven for places near to each other. The effects are definitely localised.

C. Local Storms: In addition to these storms, there are other local afternoon disturbances occuring in Sind. They are due to convectional current and contrasts of weather such as high temperature, diurnal range of temperature and differences in humidity, which cause thunderstorms, dust storms and squally weather, whenever there is the transition stage between the two seasons, e.g., (1) March to May and (2) September to November. During these months the subcontinent is not affected by storms from abroad and it becomes "an independent meteorological area". They occur in Sind and the Punjab and it is generally in the afternoon when these convective movements are strongest. At times, when the influence of a passing western disturbance from the Persian Gulf synchronises with the maximum convectional conditions of the afternoon, sharp thunderstorms and squalls may occur at one station and the neighbouring station will not be affected. The results are local dew, fog, rain etc., while the general weather both at sea and in the upper air layers is more or less settled.

Flood Years and Flood Menace: Due to such meteorological and other conditions, Sind has abnormal floods in some years. The following are some of the notable flood years in Sind:

Before 1900	Since 1900
1841	1902
1858	1910

1874	1913
1882	1916
1892	1921
1895	1926
	1929

These floods are caused by two chief agencies:

1. Meteorological causes, as stated above.

2. Physical features and conditions of drainage.

There are a number of *Nais* or hill-torrents from the western highlands bringing torrents of water down into the valley below, e.g., the Gaj, the Nari. Often these flood the Larkana and Dadu Districts.

On the other hand, the annual inundations of the Indus, which flows on a bed higher in level than the surrounding country, cause floods which prove to be disastrous.

3. Artificial bund breaches.

Due to heavy floods and the force of torrents not only from the *Nais* but also of the Indus, breaches are made in the various protective bunds, causing considerable damage to the fields and human life. Such breaches are now controlled by the Public Works Department.

4. Conditions in the upper reaches of the Indus.

These are the breaking of glacier dams, e.g., Shyok glacier dam, snow melting and river damming by landships.

CLIMATIC DIVISION OF SIND

Ancient writers divided this province of the lower Indus basin into three parallel zones, viz., *Siro* (Upper), *Vicholo* (Middle) and *Lar* (Lower) Sind, and from the point of view of climate they are found appropriate, though one is tempted at present to retain only the two chief ones, e.g., the Upper and the Lower.

That these divisions are suitable for practical purposes can be seen from the following data (Average of 30 years-1901-30-India Weather Reviews - India Meteorological Department).

Condition	*Siro*	*Vicholo*	*Lar*
Mean Max. Monthly T. (June 1919) ...	117.4° F	110.8° F (1905)	96.8° F (1901)
Mean Min. Monthly T. (Jan. 1903) ...	38.2° F	47.3° F (1925)	52.2° F (1903)
Range of T			
(Seasonal) ...	69° F	46° F	34° F
(Monthly-May)	49° F	26° F	10° F
Mean Humidity (Annual)	57° F	61° F	73° F
Mean Rainfal (Annual)	3.44° F	7.22° F	7.51° F

Characteristic of the Climatic Sub-Division.

1. *Upper Sind:* Chief locality, Jacobabad; height above sea, 186 ft.; distance from the sea, 300 miles.

The dry atmosphere of the neighbouring highlands as well as the orographical features of the North West Frontier affect this region; rainfall is the lowest in Sind and temperature is the highest e.g., the highest temperature recorded recently is 127° F in June 1919. The air is generally very dry. There is a great range of temperature in winter and frost is common. The climate resembles the continental one.

2. *Middle Sind:* Chief locality, Hyderabad; height above sea, 96 ft.; distance from the sea, 125 miles.

The S.W. monsoon winds have in this region an average speed of 11 mile per hour in June. In some years rainfall is slightly higher than at Karachi. The temperatures are lower here than in Upper Sind and humidity is moderate. The range

of temperature is also much less than that at Jacobabad. Dry hot days and cool nights are summer characteristic of this sub-division.

3. *Lower Sind:* Chief locality, Karachi; height above sea, 6 feet; distance from the sea, 5 miles.

The winding coastline affects this region to some extent. This coastal and deltaic area is naturally damper, with smaller ranges of temperature and pressure. The S.W. winds in summer and N.E. winds in winter are the prevailing air currents. Rain-fall is at times a little less than in Middle Sind Humidity is the greatest and the temperature moderate throughout the year. Dampness causes muggy or oppressive weather in summer. The climate is maritime.

Seasons: In an arid sub-tropical region such as this, there are only three main seasons of nearly 4 months each.

1. S.W. monsoon season, from July to October (the retreating monsoon does not affect it appreciably).

2. Cold season from November to February.

3. Dry hot season from March to June.

In (1) the rains are not general as in Peninsular India, but only occasional; the wind direction is S.W. or S.E. and humidity is on the increase. The 15 days monsoon period is 9th July to 23rd July.

In (2) the rains are only cyclonic storms and the usual direction of the wind is N. or N.E. (Trade wind). When it does not rain and the sun shines, the weather is fine and bracing. It becomes cooler and cooler as we go from south to north ranging from an average of 60° F. at Karachi to 40° F at Jacobabad This is the touring season in the sub-continent.

In (3) the temperature of the air gradually rises to the maximum in June-July. The sun shines directly over Sind and the wind direction changes from N.W. to S.E.. The isotherm of

85° F passes through Karachi, while round about Jacobabad the mean temperature is 95° F.

CHIEF CLIMATIC FACTORS AND ELEMENTS

It is now necessary to consider the chief climatic data that are available, viz., temperature, barometric pressure, relative humidity, wind system and rainfall.

1. *Temperature:* Sind is uniformly very hot in summer and comparatively cool in winter as the records of 30 years (1901-40) clearly show.

Sind derives its heat from the following sources :

(i) The sun, which shines for the greater part of the year in cloudless skies.

(ii) The rocks which are barren and the soil which is arid, sandy and saltish and which absorbs and radiates heat quickly.

(iii) The warm N.W. winds from the Iran Plateau in summer.

At times, there blows a harmful wind analogous to the Simoom of Arabia in the Sahara, while dust-storms with whirlwinds are common in the hot weather. The eddies, as much as 10 ft. wide in dusty areas, rise to a height of some 200 ft.

There are at the same time many ways in which heat is lost and cold follows:

(i) The air is still and the sky clear and there is little humidity or water vapour in it to absorb heat.

(ii) The rocks being barren and not covered with grass, there is quick radiation of heat towards the close of the day.

(iii) Cold winds from the snowy mountains in the north and the northwest blow during winter and reduce the temperatures of Sind to a great extent.

The month of January, for example, may be very cool from cold winds in one year and from nocturnal radiation of heat in another.

Mean Maximum Temperature: The graphs for the mean maximum temperature show that there is a steady rise of temperature at Karachi from 76° F in January to 81.6° F in June which is the hottest month in the year. It then begins to fall upto 86.7° F in August and remains more or less steady in September, December and January.

The graph for Hyderabad differs slightly from that for Karachi, in that the maximum temperature is reached in May with a rapid fall up to August. In September and October there is a gentle rise and then a sudden fall again for the winter months of November, December and January.

Jacobabad is more irregular than either of the above stations. After the fall in winter there is a very steep ascent in February and March and a slight rise in April, then again a sudden rise for May until the maximum is reached in June. The fall after June is also sudden and rapid with practically no rise in October, as in Middle and Lower Sind.

Mean Minimum Temperature: The graphs of the mean minimum temperatures of the two stations of Karachi and Hyderabad are smoother than those for Jacobabad. The coldest month for all the three places is January. The fall of temperature is greater at Jacobabad in September, and again in November and December than at the other two stations.

The annual average minimum temperature at Karachi comes to 71.2° F, at Hyderabad to 68.7° F and at Jacobabad to 66.4° F only.

The coastal strip has a more equable climate than places further inland, Jacobabad faring the worst in this respect.

Fluctuations in the Three Decades (1901-30): The graphs for the average temperatures (maximum and minimum) for the whole year indicate that they were more or less steady in all the decades for Hyderabad and Jacobabad while those at Karachi fluctuated slightly. The following are the mean (mean of 30

years 1901-1930) temperatures at the three places:

Station	Max. T.	Min. T.	Average
Karachi	85.5° F	71.2° F	78.5° F
Hyderabad	93.3° F	68.7° F	81.0° F
Jacobabad	95.5° F	66.4° F	80.9° F

Range of Temperature: Both as regards the daily and monthly ranges of temperatures Hyderabad and Jacobabad differ from Karachi where the range is small, owing to the influence of the sea. But even at a little distance beyond the coast-line e.g., Drige Road, the range increases considerably.

The accompanying thermograms of Karachi show the daily range near the sea very clearly. The daily range in summer months is much smaller than in November and December. The day's temperature is the highest in the afternoon, about 2 p.m. and the lowest in the early morning at 5 a.m.

At Drigh Road the daily range is up to 35° F, at Hyderabad up to 40° F, and at Jacobabad up to 45° F.

The following table gives an indication of the monthly ranges of temperatures in Sind:

Mean Monthly Range of Temperatures

Month	Karachi	Hyderabad	Jacobabad
January	27.1° F	25.3° F	42.8° F
May	10.8° F	26.5° F	49.5° F
July	9.0° F	17.8° F	36.7° F
November	5.7° F	28.5° F	50.4° F

(Gazetteer of the Province of Sind, B. Vol.)

The monthly range of temperature increases from the coast northwards to near the Upper Sind Frontier where it rises to over 50° F in winter. It is also greater in winter than in

summer. As a result of the S.W. monsoon current the range of temperature near the coast is not so great in summer.

2. *Barometric Pressure:* Indirectly due to these temperatures, the barometric pressure is lowest at Jacobabad and highest at Karachi. The difference between the lowest pressure in July and the highest in December is (1) at Karachi, .568 inches (2) at Hyderabad .621 inches, and (3) at Jacobabad .670 inches.

3. *Relative Humidity:* There is also a great divergence in the relative humidity of the three stations. The difference between Karachi and Jacobabad amounts to 35 per cent in the months of April and May. The driest month in Karachi is December; whereas in Hyderabad and Jacobabad, it is April because there are more winter showers. At all three stations the greatest amount of humidity is in August as a result of the influence of the S.W. monsoon current. Hyderabad is distinctly drier than Karachi, but Jacobabad is drier still.

In the interior the air is dry, though hot, in summer and hence not so distressing as on the coast; after sunset the humidity is reduced for a while, the heat from the ground radiating quickly, and nights are therefore cool. As there is a great range of temperature in winter, there is also a greater increase or decrease of humidity.

Frost: Some parts of Sind are visited by frost in winter, the necessary conditions being fulfilled, viz., (i) a clear sky, so that radiation is not hampered by clouds and (ii) a calm night, when the layers of air in contact with the ground are cooled. Whenever the temperature of the ground falls below freezing point, the air in contact with it is so much cooled that the water vapour in its layers immediately above it or in the voids among the soils is condensed into ice particles or frost. This kind of frost is found frequently in Upper Sind, but rarely in Lower Sind. Some years are notable for severe and prolonged frost, causing great damage to crops e.g., during January and February, 1934.

Cloudiness: The skies in Sind are cloudy during the monsoon season and also during the months of December and January, but in other months they are very clear. As a rule afternoons are cloudier than the rest of the day.

4. *Wind System:* The above data show that the predominant wind direction in Karachi is westerly for over four months of the year. During the months of May to September, the general wind direction is S.W., and during the winter months of November, December, January and February, it blows from the N. E., while in the intermediate months, before and after the summer season, the direction changes to N.W. It rarely blows from the south or east.

At Hyderabad, the S.W. direction is the most conspicuous from April to October, while in winter the N. W. direction prevails.

At Jacobobad there is practically no wind for half the year. During the other half the direction swings from S. E. to N.E. in the hot season, and from N.E. to N.W. in winter.

The influence of the S.W. monsoon wind reaches nearly a hundred miles inland, and so in summer evenings are generally cool at Hyderabad.

Near the seashore the wind velocity is greater while in Upper Sind it is generally calm for nearly half the year. During the cold weather months, the wind velocity varies from about 6 miles in Lower Sind to only about 1.5 miles in Upper Sind. It begins to increase from March and April until it reaches its maximum velocity of about 15 miles in Lower Sind, about 11 miles in Middle Sind, but only about 4-5 miles in Upper Sind. With the occurrence of dust storms and cyclonic rains, the wind velocity is naturally higher.

Local Land and Sea Breezes: No special study of winds prevailing locally, at the different centres, has yet been made except at Karachi. Recently owing to the requirements of the Drigh Road

Airship Base and Aerodrome and as a result of the facilities available at the Meteorological Observatory there, Dr. Ramdas has produced a valuable paper on the local afternoon sea-breeze at Karachi, occurring during the non-monsoon period of October to March. This breeze is calculated to be a result of the difference in temperature and pressure above land and sea and due to the difference in solar insolation. His finding is that 'the breeze sets in during the afternoon and has some of the characteristics of a cold front: it sets in suddenly, is usually, colder, more moist and has a greater velocity than the preceding land breeze'. This land breeze, again, is part of the prevailing winds at lower levels over the whole of Sind: the normal direction and strength of the winds are determined by the position and intensity of the seasonal anticyclone over North West India.

The general characteristics of the breeze have been summarised as under:

"The sea breeze first sets in at Manora, then moves towards Drigh Road through Karachi City. The time taken by the sea breeze to reach the Airship Base varies from 1 to 3 hours. Before the arrival of the breeze at the Airship Base, the previous land-breeze, if any, drops to calm, and the setting in of sea-breeze is accompanied by a fall of temperature (about 5° F to 3.5° F), rise of humidity (from 5% to 30% and above), shift of wind direction to west-south or south-west, and an increase of wind velocity...

"The transition from land breeze to sea-breeze is more and more marked as the latter proceeds inland. The sea-breeze front appears to be somewhat diffuse near the coast but by the time it reaches the Airship Base, it becomes quite sharp owing to increased contrast with the land breeze."

It has been also noticed that this sea-breeze is not the actual gradient wind, i.e., westerly and north-westerly breeze, but owing perhaps to the hills to the north-west and north of Karachi, it is deflected largely to the west-south and south-west direction.

Thus it can be seen that in the climatic elements of temperature, barometric pressure, humidity and wind system, Sind in general has three distinct regions differing from one another. How far precipitation agrees with this analysis has to be seen now.

5. *Rainfall in the Lower Indus Basin:* Sind is called an 'Unhappy Valley', perhaps on account of its scanty rainfall. 'The Hindus of Sind', says R. F. Burton, 'have a tradition that Hiranyakasipu, the demon king of Multan, was powerful enough to draw down Megha Raja, the cloud-god from heaven and compel him to promise never to visit the Valley of the Indus.'

The orographic features of Sind lend support to such a belief. The average height of the surrounding hill ranges is only about 5000 ft. while the Laki Hill lying in Kohistan just reaches a little above 2,000 ft. To catch the monsoon current a high mountain within the region is required. Against the alignment of the two ranges of mountains bordering the frontier west, which is very low, any clouds that are caught by storms are again lost in them. Particularly in the case of Sind in winter, 'the seat of maximum pressure is not the seat of maximum rainfall; nor indeed is the cause of the great summer depression of Upper Sind and Lower Punjab of any precipitation whatever'.

But though the rainfall is meagre, it is a useful supplement to the underground supply of water in many parts of Sind.

Annual Rainfall: Being a portion of the dry monsoon belt, this region receives very little rainfall. It has very few rainy days, during the year; year after year, the average rainfall at any station, does not amount to 10 inches.

A special feature of the rainfall curves in Sind is that there are peaks of good rains and troughs of droughts at an interval of 5-6 years. It is remarkable that while there are a number of years of great scarcity of rainfall, there are abnormal rains and

floods. Also, these do not always coincide in all the three climatic divisions, e.g., while 1926 was a flood year for Karachi, there was only 4.28 inches of rainfall at Jacobabad. In 1929, Hyderabad received 23.13 inches but Karachi only 4.13 inches. Nearer the coast, rainfall is greater than in Upper Sind, where the average is only 3.44 inches.

Distribution of Rainfall: In the matter of distribution of rainfall in Sind, Nagar Parkar stands by itself. Not only does it receive the advantage of its hight but it touches to some extent the fringes of the S.W. monsoon current. Middle Sind receives slightly more rain than Lower Sind in some years, while there is hardly any rain (less than 2 inches) in parts of Upper Sind. Even in years of great floods there is not more than 10-12 inches of rainfall in this - the driest part of the Province.

Mean Annual Rainfall: (India Weather Reviews)

Place		Mean Annual Rainfall	Rainy days
Lower Sind	Nagar Parkar	14.85	17
	Tatta	8.83	8
	Karachi	7.51	9
Middle Sind	Umerkot	8.96	12
	Hyderabad	7.92	9
	Nawabshah*	9.55	9
	Mirpurkhas*	6.05	7
	Naoshero	4.26	6
	Sehvan	5.41	8
Upper Sind	Sukkur*	2.74	5
	Shikarpur	3.39	6
	Larkana*	3.55	5
	Jacobabad	3.44	7

Stations marked * have the averages taken for 17 years (1914-1930). The rest have those for 30 years (1901-30).

At Sukkur the average rainfall is the least i.e., less than 3

inches, while at Nagar Parkar it is the heaviest, i.e., nearly 15 inches. At the intermediate stations it varies from about 5 inches to 10 inches. Also the average rain per day is a little less than 1 inch, the total number of rainy days amounting to 7 only.

Mean Monthly Rainfall: Although there are two distinct seasons of rainfall, viz., summer and winter, the available data show that, on the whole, it is not only precarious and fitful, in both of them, but also scattered thinly throughout the year. The amount is, however, more in summer than in winter. The actual monsoon period during the year is from 9th July (commencement) and 23rd July (withdrawal).

Rainfall in Kohistan and the Desert Province: In the matter of the distribution of rainfall in Sind, the data for Kohistan are very important, as they give an indication of the periodic supply of rain water in the Malir Basin, which is the main source of Karachi's water supply. Here too the peaks of good rainfall alternate with the years of drought.

Although the rainfall in Kohistan is usually scanty, there are years in which it increases to over 15 inches, e.g., in 1916. It is even more at Khadeji than at Karachi in some years. There is, therefore, plenty of underground water secured by percolation and absorption in the deeper strata of rock in the dry river basin. These peak years are also a guarantee for Karachi's subterranean water supply in the Malir Valley against the proposed Indus scheme.

Even in the region called the Thar Desert there are good, though occasional, showers and years of floods. The following is the average rainfall (Data form P.W.D. Sind) in the different Talukas of Thar Parkar:

Average rainfall (avg. for 25 years).	Sinjoro	Mirpur-khas	Jamesabad,	Dighri,	Samaro,	Sanghar,	Umer-kot
1910-1935	6.49	9.02	9.16	7.99	13.5	6.59	9.39

A portion of this rainfall is due to winter showers, which account for water existing in a number of *Dhands* or lakes in the Thar and the Pat Sections and affording camel pasture in cool season.

Reason for Scarcity of Rainfall: Apart from the fact that Sind usually escapes the influence of both the monsoons, there are other reasons for such scarcity or irregularity of rainfall.

(1) In the first place, the arrival of the S. W. monsoon is rather late in Sind and the season is short. It does not burst here in May-June, when the land is hottest (mean maximum temperature at Jacobabad being 113.7° F), but in July when the temperature is lower (mean maximum temperature being 108.5° F), and the chief pressure gradient is over the Peninsula and the Bay of Bengal. The reason is that the upper air current over N.W. India, flowing from the west and north-west during the season is warm and dry with low humidity and this descends a couple of thousand feet against the S. W. monsoon current.

(2) The northern parts of India get very cold in winter, the Himalayan snows melt slowly in early summer and so the high pressure over the area takes time to turn into a low pressure system, which is essential for the necessary indraught. Hence the delay in the actual arrival of the rainy season in the Indus Valley and the reduction in the number of rainy days. Also, the more the snowfall in one winter season on the mountains, the poorer the prospects of rains in the plains the following summer.

(3) As the monsoon season advances, and the lowest pressure is well within the angle between the Kirthar and the Hima-

layan Mountains, the air can only flow in here from the south and east and so only a portion of the monsoon current containing a little moisture can pass over the Province.

(4) The land being exceptionally and increasingly hot from south to north, e.g., mean temperature 85° F at Karachi to 95° F at Jacobabad, the humidity is relatively reduced, from 80% to 50% only. The high temperature is also further increased on account of the dry heat and the absence of low clouds.

(5) The air current over the N. W. must rise some 3,000 ft. above the sea-level before any appreciable precipitation can take place. Such is not the case in Sind, and the upper layers of air being warm and dry, they do not allow the formation of low clouds over the land. While in North India and in the Ganges basin rainfall increases as we approach high mountains, in the Indus basin the reverse is the case, precipitation decreases considerably on the western highlands.

Variability of Rainfall: Not only is the rainfall in Sind scarce but it is also irregular, so that for every one season of good rains, there are two or three, or even more, of drought. At times a whole season's rain falls in couple of days and there is prolonged scarcity for the rest of the year. The result is terrific floods and destruction of crops at one time and severe drought at another. 'Over the Indo-Gangetic Plain, variability is at a maximum in Central Sind, which is at once the seat of the most niggardly and also the most variable rainfall in the whole of India. The noticeable improvement in reliability is of little, if any, economical significance; for throughout Sind, Bhawalpur and Western Rajputana, a variability of over 30 per cent combines with an average rainfall, which is nowhere greater than 15 inches and for the most part is considerably less.'

In Sind and Cutch the annual percentage deviation from the average is $\times 37$ (mean) $+124$ (max.) - 53 (min.), this is unique in the whole of the Indo-Pakistan subcontinent.

The following table of comparative variability is significant:

Station	Average Annual rainfall	Variability
Naoshero (Sind)	5″	53%
Cawnpore (U.P.)	34″	20%
Calcutta (Bengal)	65″	11%
Rohri (Sind)	6″	65%
Sirsa (Punjab)	12″	46%
Lucknow (U.P.)	35″	28%
Darbhunga (Bengal)	44″	20%
Barisal (Bengal)	62″	16%

This shows that while the normal yearly rainfall increases from a minimum in Sind to a maximum in Bengal, the variability is the reverse. 'The province in which the annual variations as compared with the general average are greatest is Sind and Cutch.'

In this region, again, there is a variability of summer rainfall of 40 percent to 60 per cent from the desert in the east to that of 15.20 per cent on the highlands in the west.

Even during the different months of the monsoon season the variability is different in different regions of the Indo-Gangetic Plain, the worst sufferer being Sind:

Month	Region I	Region II	Region III A	Region III B	Region IV
June	70	65-75	60-75	60-75	45-60
July	60	45-75	40-50	40-50	30-40
August	70	40-70	40-50	40-50	35-50
September	90	80	60-75	60-75	45-60
October	100	100	100	100	75

Thus the rainfall in the lower Indus basin is not only scanty but also irregular and unreliable; so one cannot speak of normal

rainfall figures for any station in Sind. 'Within the Middle and Lower Indus lowlands, the so called normal rainfall figures are anything but indicative of conditions from year to year.'

In the case of Karachi over a period of a third of a century, the normal rainfall was 6.3 inches although half of the seasons' precipitation was no more than 4.3 inches. In three seasons, the rainfall amounted to a little over 20 inches.

CYCLICAL PERIOD

This leads us to the consideration of a cyclical period in Sind. There is no doubt that the floods come periodically but to establish a cycle of a certain number of years is a most difficult meteorological problem. Blandford established a cycle of 11 years from certain meteorological calculations which, however, do not tally with the data collected in this region in recent years. He marked the relationship between weather and sunspots, the maximum of which occured at intervals of 11 years. 'But the actual amount of surface covered at each maximum is very irregular.'

Another argument advanced in favour of a cycle of 11 years is that it tallies with the main daily range of magnetic delineation, according to Prof. Balfour Stuart. But in this case also we have to deal with very irregular curves. It may be that there are other unknown influences working out a cyclical period. The temperature and rainfall in a particular area are caused by storms and depressions, which cannot be accurately gauged or forecast at present. But it can be said with a certain amount of accuracy that any alteration in the solar heat may modify the formation of cyclones and so a cyclical period.

There is, again, the possibility of connecting years of drought with the years of heavy snow-fall on the Himalayas, as too much snow may cause prolonged suspension of summer rainfall. Droughts may also be due to unseasonable persistance of dry land winds. Another strange coincidence is that a drought in

the Peninsula is followed by one in the North of the subcontinent e.g., 1876 Deccan drought, 1877 Punjab drought.

So far as the region of our study is concerned, a cycle of 11 years is quite out of question. In very recent years a cycle of 6-7 years is noticeable, viz., 1902, 1908, 1910, 1913, 1921, 1926, 1932.

CLIMATIC CHANGE

Is the climate of Sind also changing? There are several records to show that Sind experienced a better and more congenial climate in per-historic days. 'It is related by the chronicles of antiquity that in days gone by, in ages that have long fled, Sind was a lovely land, situated in a delightful climate, a fertile plain traversed by the beneficent Mihran with large flourishing and populous cities, orchards producing every kind of tree and fruit, and gardens that were the reflections of Iran and the envy of the seven Heavens.'

The remains of Mohen-jo-Daro and of other kindred sites distinctly indicate a wetter Sind in the pre-Aryan period.

The admirable researches of Sir Aurel Stein in Baluchistan and Waziristan show that the climate of Central Asia must have been 15-20 inches average rainfall annually. He thinks that the northern storm belt was then deflected by arctic pressure further south. At the same time a deflection of the S.W. monsoon current is also suggested. On the whole, all the dry Afrasian belt was covered by westerly rain storms in that age.

Dr. C. W. Normand, sometime Director of the Meteorological Department of India, has opined that more rain in the summer season was possible in Sind and Baluchistan at the time of the Indus Valley Civilisation, "as a very much greater change in meteorological conditions is required to explain a copious rainfall in winter, unless a change in the orography of Sind's surroundings is simultaneously postulated".

Mr. Majumdar is also of opinion that from the presence of

many drains and pripes and burnt bricks of Mohen-jo-Daro, figures on seals of animals living in moist climate such as rhinoceros, tigers and elephants and of trees on painted pottery, it can be surmised that Sind must have seen wetter years in the milleniums before Christ. Remains of elephants and rhinoceros are actually found on the eastern side of the Kirthar Range.

Burnt bricks and not baked ones were used in Sind in those pre-historic times. Even in the remains of Bahmanad discovered by Bellasis, such burnt bricks were used, suggesting a greater rainfall.

Raverty has noticed in Arabic geographers a reference to the green (*Hariana*) and cultivable lands now lying barren. A big forest between Lakhi and Khanpur in the Larkana District was actually utilised by the Daudpotas for their *Shikargahs*.

That the climate of Sind has become gradually drier to-day than at the time of Mohen-jo-Daro is also attested by Dr. Mackay from the rapid deterioration of brick which is now taking place compared with those beautifully preserved in the buried city. 'This state of things was due to the fact, that the plain round the city was then well watered and consequently the destroying action of the salt was checked, although as we know the buildings needed frequent repairs.'

In this matter of climatic change the climatic tables of two sets of normals for the three stations, Karachi Hyderabad and and Jacobabad, covering two long and distinct periods are also suggestive.

Whatever the meteorological conditions of Sind may have been in past ages, the rainfall recorded for the past six years does not give any indication of a change of climate. The year 1933 was only a flood year for Karachi while in 1935 and 1936 the rainfall at the station was decidedly poor, and Hyderabad has fallen below the average.

There is a suggestion made by some writers that the Sukkur

Barrage which is fully functioning since 1932, would help Sind to secure more rains. But such an expectation is too premature. Considerable data must be collected and more time must elapse before the meteorologists of Sind can come to any definite conclusion. It is not impossible that more extensive water supply, perennial irrigation, afforestation and continuous evaporation may cause slightly greater precipitation of rainfall in Sind in the years to come. Says Blanford: "Of the influence of local evaporation in enhancing rainfall, one or two instances are given; especially that of Yarkand and that of the irrigated tract bordering the Indus in Sind and the lower Punjab."

SUMMARY

In no other region of the subcontinent are the climatic conditions more unusual, irregular and unstable than in the lower Indus basin. It is the driest and hottest of all provinces, aridity being its commonest feature, e.g., Jacobabad has a mean maximum temperature of 113° F and mean humidity of 41 per cent. The thermal equator passes through Sind. These conditions are accentuated by its physical features, the Thar Desert in the east, the sea in the south and the Halar-Suleiman (Kirthar) Mountains with their peculiar re-entrant angle, in the west and northwest. Thus the temperatures are exceptionally high in summer but in winter they are comparatively low. The diurnal range of temperature is also great (e.g., over 45° F in a single day at Jacobabad). Nearest the sea coast, the daily range of temperature is least. The monthly range increases from south to north and from summer to winter (e.g., Jacobabad has a summer range of temperature 42° F and winter range 50° F). The greatest humidity occurs in August, viz., 75, but the least in December, viz., 58 in Lower Sind and 47 in April in Upper Sind. Thus the weather is drier and hotter but more bearable in the north than in the south. The skies are generally clear and frost is not uncommon. While in Upper Sind it is generally calm for nearly half the year; nearer the coast of Sind, the

wind velocity is about 15 miles per hour in the monsoon season. Dust storms and squally weather are common at the beginning of the two chief seasons. The predominant wind direction at Karachi is westerly before the monsoon season begins, while in winter the direction is north-east or north-west. In Upper Sind it varies from south-east to north-east in summer and from north-east to north-west in winter.

The region suffers most in the matter of rainfall. It is not only precarious and scanty but also the most variable of the subcontinent, the orography of Sind is mainly responsible for it. What little precipitation it gets is often due to cyclonic storms, caused by eastern and western disturbances, particularly the former. The average rainfall is about 7 inches in Lower Sind and about 3 inches in Upper Sind, with only about 8 rainy days in the whole year, July being the rainiest month. The greatest peculiarity about the rainfall curve is that after gaps of six or seven years of scarcity, there are peaks of good and at times heavy rainfall, although the cyclical period is hard to determine. It is a question whether there is any real progressive climatic change in Sind, as the history of the Province shows that there may have been greater rainfall in the past when forests existed. It is equally difficult to say whether the Sukkur Barrage drainage system will influence future rainfall. Even with perennial irrigation, afforestation and continuous evaporation it is not certain whether Sind will see wetter days.

APPENDIX I

General Weather Conditions in Sind Month by Month.

January.

Coldest month of the year.
Western disturbances affect the region.
Cold waves, rain, squally and northerly wind expected.
Dust storms and frost are likely.
Mean temperature - Max. 74.8° F: Min. 50.4° F.

Mean rainfall - .12 inches.

Mean Baro pressure - 30.005

Mean humidity - 60%

General wind direction - N.W. N.W.

February

Meteorological conditions similar to those in January.

More winds; Chilly weather.

More westerly depressions; Rain expected.

Mean temperature - Max. 78.8° F; Min 54.2° F.

Mean rainfall - .21 inches.

Mean Baro pressure - 29.950

Mean humidity - 59%

General wind direction - N.W. N.W.

March

Dry weather, clear or partially clouded skies.

Rather dusty month.

Early mornings foggy near the coast.

Western disturbances still occur with scattered showers.

Mean temperature - Max. 88.7° F; Min. 63.7° F.

Mean rainfall - .18 inches.

Mean Baro pressure - 29.835

Mean humidity 56%

General wind direction - N.W.

April

Winter conditions disappear and summer conditions appear.

S.W. wind begins to blow across the region.

Dust storms at times; practically no rainfall.

Mean temperature - Max. 96.6° F; Min. 72.1° F.

Mean humidity 56%

General wind direction - S.E.

May

Arabian Sea storms begin to affect Sind.

(Tropical Sea storms of the Arabian Sea enter Sind Coast, once in 12 months)
Practically dry weather, Cloudiness increases.
Moderate to strong surface winds from S.W.
Dust storms expected.
Mean temperature - Max. 102.8° F; Min 79.3° F.
Mean rainfall - .15 inches.
Mean Baro pressure - 29.500
Mean humidity 60%
General wind direction - S.E. & S.W.

June

Hottest month of the year.
Monsoon condition, but with practically no rain.
Wind current stronger than in May.
Rough seas and swells.
Coasting steamers stop sailing.
Mean temperature - Max.103.3° F; Min 83.1° F.
Meam rainfall - .33 inches.
Mean Baro pressure - 29. 429
Mean humidity - 63%
General wind direction - S W. and S.E.

July

Rainiest month of the year.
Monsoon current reaches the interior.
Humidity is expected to increase.
Western depression on rare occasions; wind and rain.
Wind current strong.
Mean temperature - Max. 99.2° F. and Min. 82.8° F.

August

Milder weather prevails.
More cloudy and less rainy month.
Visibility is moderate.
Wind direction - S.W.

Eastern depressions sometimes occur.
Mean temperature - Max. 95.3° F; Min. 80.2° F.
Mean rainfall 1.90 inches.
Mean Baro pressure 29.473
Mean humidity 75%
General wind direction - S.W. S.E.

September

Receding monsoon.
Eastern disturbances sometimes expected.
Dust-storms and squalls are fewer.
Wind velocity reduced.
Mean temperature - Max. 95.4° F; Min. 74.4° F.
Mean rainfall .82 inches.
Mean Baro pressure 29.624
Mean humidity 73%
General wind direction - S.W. S.E.

October

Dry and clear month.
Only late Arabian Sea depression.
Practically no rain.
Temperature rises slightly at times.
Wind direction now alters.
Sea is smooth and coasting steamers begin to ply.
Mean temperature - Max. 94.9° F; Min. 70.0° F.
Mean rainfall - .06 inches.
Mean Baro Pressure 29.799
Mean humidity 63%
General wind direction - S.W. N.E.

November

Wind direction changes from W.SW. to N.NW-, NE
Pleasant month; without any showers of rain
Western disturbances on occasions bring drizzles rarely
Mean temperature - Max. 87.4° F; Min. 59.7° F

Mean rainfall - .063 inches
Mean Baro pressure 29.937
Mean humidity 57%
General wind direction N.E. N.W

December

Squally weather expected
Western disturbance come in at times
Pleasant month
Wind directions changes to N and N.E.
Winter showers expected
Mean temperature - Max. 77.6° F; Min. 51.8° F
Mean rainfall .10 inches
Mean Baro pressure 30.010
Mean humidity 60%
General wind direction - N.W. N.E.

N. B. — The above summary of the weather conditions for the whole Sind is based upon the climatic data for the three main stations in Sind, viz., Karachi, Hyderabad and Jacobabad.

APPENDIX II

KARACHI (Manora)

	Temperature Max.	Min.	Pressure	Humidity per cent
January	75.7	58.5	30.095	63
	76.0	56.7	30.090	61
February	78.2	61.5	30.067	66
	77.7	59.5	30.062	67
March	81.8	66.3	29.954	67
	83.1	67.3	29.938	71
April	85.3	74.0	29.836	79
	87.0	74.1	29.831	76
May	88.8	78.3	29.737	80
	90.2	78.9	29.723	78
June	91.0	82.4	29.577	80
	91.6	82.4	29.560	79
July	88.2	80.4	29.540	83
	89.6	81.3	29.522	82
August	85.5	77.7	29.621	85
	86.7	78.5	29.599	84
September	85.6	75.8	29.765	82
	86.8	76.9	29.747	82
October	86.6	73.0	29.918	73
	88.5	73.5	29.902	74
November	84.3	66.7	30.039	66
	86.1	65.3	30.024	62
December	78.2	59.6	30.100	58
	79.2	58.8	30.090	58
Annual	84.1	71.2	29.853	73
	85.1	71.2	29.853	73

HYDERABAD

	Temperature Max.	Min.	Pressure	Humidity per cent.
January	76.2	50.6	30.006	57
	75.8	50.5	30.006	61
February	80.5	54.0	29.953	56
	80.4	54.0	29.941	58
March	92.6	64.0	29.848	50
	92.5	63.5	29 834	53
April	192.0	72.1	29.719	47
	101.2	71.6	29.710	52
May	107.0	78.2	29.601	54
	107.0	78.1	29.589	55
June	104.2	81.7	29.452	62
	104.6	82.0	29.432	64
July	99.2	80.9	29.410	68
	99.6	81.7	29.391	69
August	95.9	79.0	29.486	70
	99.5	79.6	29.467	72
September	97.4	76.2	29.635	68
	96.7	76.6	29.619	70
October	97.9	70.1	29.809	56
	97.5	70.8	29.796	61
November	89.1	58.9	29.942	52
	88.9	60.5	29.935	55
December	79.0	52.3	30.025	55
	87.2	52.1	30.012	59
Annual	93.4	68.2	29.741	58
	93.3	68.7	29.728	61

JACOBABAD

	Temperature Max.	Min.	Pressure	Humidity per cent
January	73.0	43.2	29.915	64
	72.7	44.1	29.921	65
February	77.8	48.2	29.855	55
	77.5	49.1	29.827	54
March	90.7	59.7	29.743	45
	90.7	60.5	29.733	45
April	99.6	70.6	29.603	41
	101.8	78.3	29.597	41
May	112.0	78.3	29.466	42
	111.3	78.1	29.460	43
June	113.9	84.3	29.316	55
	113.7	85.1	29.295	57
July	108.5	84.6	29.280	66
	108.5	85.6	29.260	65
August	104.6	81.9	29.361	72
	103.9	82.5	29.353	71
September	103.7	76.2	29.515	71
	102.9	76.0	29.506	68
October	99.2	63.2	29.709	56
	98.8	65.7	29.699	56
November	87.8	51.8	29.856	57
	87.3	53.5	29.852	56
December	76.7	44.3	29.938	66
	75.5	44.7	29.930	63
Annual	95.5	65.5	29.630	58
	95.5	66.4	29.621	57

The figures given at the top of each column show the summer years of which the latter are normals. At Karachi, the conditions are nearly the same except a slight rise in the maximum temperature. Humidity is doubtless increased at Hyderabad while at Jacobabad the range of temperature is reduced; so also the barometric pressure and humidity.

APPENDIX III

Rainfall Normals.

Month	Nagar Parkar *14—30	Thatta 32—30	Karachi Manora 31—30	Umerkot 32—30	Hyderabad 41—30	Naoshero 20—30	Sehvan 31—30	Sukkur Rohri 32—17	Shikarpur 32—30	Jacobabad 42—30
Jan.	0.03	0.28	0.63	0.17	0.24	0.25	0.35	0.25	0.29	0.33
	0.03	0.11	0.31	0.09	0.12	0.15	0.23	0.04	0.14	0.33
Feb.	0.22	0.42	0.48	0.13	0.28	0.31	0.32	0.26	0.36	0.32
	0.15	0.37	0.46	0.14	0.30	0.22	0.27	0.15	0.22	0.20
Mar.	0.10	0.13	0.23	0.15	0.15	0.21	0.13	0.19	0.29	0.28
	0.07	0.21	0.34	0.17	0.28	0.18	0.14	0.14	0.25	0.26
April	0.06	0.18	0.17	0.09	0.06	0.03	0.19	0.18	0.16	0.16
	0.01	0.04	0.07	0.01	0.08	0.03	0.14	0.08	0.08	0.20
May	0.06	0.07	0.08	0.06	0.13	0.07	0.15	0.68	0.12	0.13
	0.27	0.21	0.10	0.07	0.15	0.15	0.08	0.27	0.07	0.13
June	0.42	0.68	1.03	0.65	0.51	0.46	0.53	0.14	0.13	0.15
	0.64	0.61	0.57	0.36	0.36	0.30	0.28	0.06	0.21	0.36

*These figures indicate number of years respectively taken for the two normals in the case of each place.

(continued on page 151)

Month	Nagar Parkar 14—30	Thatta 32—30	Karachi Manora 31—30	Umerkot 32—30	Hyderabad 41—30	Naoshero 20—20	Sehvan 31—30	Sukkur Rohri 32—17	Shikarpur 32—33	Jacob-abad 42—30
July	5.70	4.00	2.95	3.00	3.17	1.15	1.66	0.74	0.69	0.13
	6.18	4.48	2.76	3.79	3.43	1.20	2.14	0.86	0.72	0.82
August	5.27	1.83	1.39	2.32	2.06	1.15	1.31	1.01	1.07	1.17
	4.52	2.09	1.85	2.72	2.12	1.11	1.22	1.90	1.02	0.70
Sept.	1.20	0.54	0.51	0.96	0.58	0.37	0.31	0.08	0.20	0.19
	2.49	0.58	0.78	1.34	0.93	0.67	0.72	0.18	0 46	0.28
Oct.	0.04	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01
	0.39	0.02	0.03	0.13	0.00	0.00	0.00	0.05	0.04	0.06
Nov.	0.10	0.14	0.17	0.05	0.09	0.02	0.08	0.08	0.18	0.18
	0.04	0.04	0.10	0.01	0.03	0.02	0.03	0.05	0.01	0.02
Dec.	0.03	0.07	0.15	0.04	0.00	0.10	0.09	0.10	0.16	0.11
	0.04	0.05	0.15	0.03	0.10	0.13	0.16	0.11	0.17	0.48
Annual	13.23	8.34	7.79	7.53	7.32	4.12	5.15	3.12	3.58	4.06
	14.85	8.83	7.51	8.96	7.92	4.26	5.41	2.74	3.39	3.44

It must be noted that there is a tendency for increasing rainfall at some stations in Lower and Middle Sind, and that this increase is chiefly in summer rains (specially July).

APPENDIX IV

Annual Rainfall (Inches)
(At Manora)

Year	Inches	Year	Inches	Year	Inches
1856	1.88	1886	9.49	1916	21.87
1857	6.58	1887	3.33	1917	5.63
1858	7.75	1888	4.94	1918	2.04
1859	6.10	1889	4.88	1919	3.39
1860	2.76	1890	13.12	1920	1.97
1861	6.74	1891	2.42	1921	16.90
1862	4.81	1892	11.96	1922	1.99
1863	13.67	1893	12.21	1923	5.57
1864	6.18	1894	22.71	1924	3.69
1865	6.95	1895	4.85	1925	4.38
1866	13.51	1896	11.66	1926	20.04
1867	2.32	1897	12.07	1927	8.90
1868	2.26	1898	3.24	1928	2.39
1869	28.00	1899	0.63	1929	4.13
1870	4.57	1900	1.99	1930	16.70
1871	0.47	1901	1.3	1931	0.73
1872	7.48	1902	18.23	1932	12.78
1873	2.46	1903	4.58	1933	20.11
1874	8.40	1904	4.62	1934	8.44
1875	9.51	1905	3.64	1935	3.45
1876	5.40	1906	6.47	1936	4.21
1877	2.09	1907	7.75	1937	11.73
1878	23.83	1908	6.45	1938	4.73
1879	1.92	1909	7.09	1939	4.54
1880	4.09	1910	12.63	1940	10.85
1881	4.84	1911	4.84	1941	1.91
1882	6.11	1912	3.17	1942	13.11
1883	7.27	1913	13.45	1943	2.93
1884	4.82	1914	9.34	1944	26.63
1885	?	1915	2.26	1945	7.53

1946	3.92	1948	5.40	1950	?
1947	2.33	1949	12.20		

According to I. Met. D. Memoirs Vol. VI the annual rainfall at Manora in 1881, 1882, 1883 and 1884 was 6.02″, 10.54″, 6.11″ and 7.27″ respectively.

CHAPTER V

SOILS

The factors of soil formation viz. physiography, nature of rocks, climate etc. have been already dealt with in the previous Chapters. How they affect other inorganic conditions and organic life, can now be understood. It is remarkable that 'sorting' has been going on everywhere, for millions of years and according to the physiographical and hydrographical conditions prevailing.

There are several varieties of soils in Sind, derived from the rocks which are mainly limestones and sandstones in situ, and from the drifted silt, mud, sand and gravel from the distant Himalayan heights. The first belt is that of calcareous arenaceous soils, while the second consists of sand and silt in a kind of net work spread all over the valley proper. There are light soils, containing more sand and a little clay, while others are heavy soils containing more clay and a little sand. There are also soluble salts impregnated in the soils, making them full of *Kalar* and uncultivable. In the Western Valley section, the soil consists of old alluvium, while in the Eastern Valley section it is recent alluvium. Besides this, the soils of Sind are classified from the point of view of the crops yielded by them. The main divisions of the valley soils are :-

Old soil divisions made by the Sindhis.

Kind of soil	Crops to sustain	Typical.
1. *Wariasi* (Loose sand)	Any crop including cotton if manured and watered;	Umerkot and Thar-parkar District

	ground nuts till and garden roots are common.	
2. *Kacho* (Flood silt)	Almost all crops *(Kharif* and *Rabi)* Rice, wheat, *Jambho* etc.	Hyderabad District and Delta.
3. *Chiki* or *Paki* (Hard baked and submerged)	Rice, wheat, etc.	Larkana District
4. *Kalar* (with excess of salt).	Rice, cotton.	Khairpur Taluka

CHEMICAL ANALYSIS OF SIND SOILS

The soils of Sind, derived mainly from rocks and the drifted silt, are sandy alluvial in character and the Valley section comprises of alternate layers of sand, sandy loam, loam and sometimes clay loam. The soil profile in Sind, therefore, is structureless and irregular in composition on account of vagarious flow of the River Indus and varying quantity and grade of the drifted river silt. The following table gives the mechanical analysis of the typical Soils of Sind:-

Table showing Mechanical Analysis of Soils from Sind

Fraction	Kohistan Tract		Central Alluvial Plain		Tharparkar	
	Surface %	Subsoil %	Surface %	Subsoil %	Surface %	Subsoil %
Clay and Finest Silt	8.89	7.80	15.67	15.43	5.23	10.71
Fine silt	1.70	2.12	8.52	5.90	0.74	1.44
Medium Silt	0.39	1.76	7.88	7.60	0.40	0.26
Coarse Silt	2.21	3.94	48.23	49.37	1.93	2.24
Fine sand	35.15	44.74	19.52	21.50	30.41	25.12
Coarse sand	51.66	39.6	0.18	0.20	61.29	60.23
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table showing Distribution and Classification.

(The soils of Sind of which the mechanical analysis are given above, show the following distribution and classification.)

Tract	Clay Portion %	Sandy Portion %	Class of soil
Kohistan Tract			
Soil	10.98	89.02	Sandy
Sub soil	11.72	88.38	-do-
Central Alluvial			
Soil	22.07	67.93	Sandy loam
Sub soil	28.93	71.07	-do-
Tharparkar			
Soil	6.73	93.63	Sandy
Sub soil	12.41	87.59	-do-

Chemical composition of Sind soils:-

The Sind soils show alkaline reaction (pH 8.4-8.7) on account of the pressure of Lime. They are generally deficient and Lime (CaO) excepting the Tharparkar Soil which are deficient in lime contents, as will be seen from the following table.

Table showing Chemical analysis of soil of Sind.

	Kohistan Tract		Central Alluvial Plain		Tharparkar	
	Surface-soil %	Sub-soil %	Surface-soil %	Sub-soil %	Surface-soil %	Sub-soil %
Moisture	0.38	0.54	0.80	0.2	0.42	0.54
Low on ignition	3.78	4.40	5.40	4.34	1.84	2.06
Silia and insoluble silicates	73.90	73.34	74.82	76.28	90.52	88.40
Lime as CaO	8.18	8.01	3.36	3.92	0.28	0.56
Magnesia as MgO	0.50	0.50	0.40	0.50	0.40	0.50

Potash as K_2O	0.17	0.31	0.29	0.31	0.19	0.15
Phosphoric Acid as P_2O_5	0.06	0.054	0.048	0.028	0.043	0.043
pH	8.6	8.7	8.6	8.7	8.6	8.4

Thus the Sind soils show quite a good lime-Magnesia ratio varying from 8:1 to 16:1 in all tracts excepting in the tharparkar where it goes as low as 3:4 or 1:1. The physico-chemical properties of the soils in relation to plant growth are ideal in Sind. In the Punjab, on the other hand, the soils are alkaline as they contain sodium carbonate which is toxic to plants, and in the Deccan trap area, the soils are acidic as they are leached excessively on account of the greater rainfall.

SAKRAND FARM INVESTIGATION

The research work carried out at the Sakrand Research Farm in this connection is valuable. The following are some of the results:

(1) Water is generally struck at about 30 feet below the surface and in a sandy layer.

(2) The average virgin soil in Sind is not rich in nitrogen content but its nitrifying and nitrogen-fixing powers are great and so the fertility is not lowered by cropping.

(3) There are three main classifications of soils in the valley — Northern, Central and Southern. The soils of a lighter type exist in the north, those of a medium type in the central, while there are very heavy soils in the south.

Those containing more fine sand and silt but little clay are light soils and are well drained, e.g., the physical properties of the soil at Sakrand are:-

Fine sand	Silt	Clay
50 %	30%	14%

The maximum water-holding capacity is low, varying between 40 and 55. The highest quantity of water, found in

the soil 24 hours after an 8″ irrigation, is 28%.

The hygroscopic coefficient of the soil is also low, viz., 15-20%.

(4) There is always a tendency for soluble salts to accumulate wherever the clay proportion is large and fine sand relatively less.

(5) The rate of percolation of water is fairly good in sweet lands i.e., without *Kalar* or soluble salts, while it is generally slower in *Kalar* soils.

(6) The soluble salts in the soil move from place to place along with water. The rate of movement of water is faster than that of the dissolved salt.

(7) A typical analysis of soil shows the difference between good and *Kalar* soils.

Table showing difference between *Kalar* soil and good soil.

Contents	*Kalar* Soil	Good Soil
Loss on ignition	7.00%	5.00%
Insoluble matter	65.00%	70.00%
Lime as CaO	6.00%	6.00%
Potash	0.95%	0.75%
Phosphoric acid	0.18%	0.15%
Nitrogen	0.045%	0.05%
Total soluble Salts	1.80%	0.20%

Soils with more soluble salts are considered to be bad and unsuitable for cultivation.

(8) *Kalar soils of Sind.*

Generally soils containing more than 0.5% of total soluble salts may be styled as *Kalar* soils. They are particularly found in the Larkana District, Dadu, Khairpur and Mirpurkhas area.

These are common in the valley - some containing as much as 7% to 20% soluble salt. Vast stretches of barren land are

covered with salt incrustations. Surface washing does not remove them nor does percolating water drive them down into deeper layers of soil. These saline soils are called 'Solom Chaks' and are entirely barren. Whereas alkaline soils are called salonietry type which are rare in Sind.

Through such a soil, water percolates very slowly.

The injurious salts commonly found are NaCl and Na_2SO_4 but they are not so injurious as real alkaline salts, Na_2CO_3 and $NaHCO_3$. They do not get easily washed and make the soil sticky and also render it water-logged. Again the nitrogen fixing power of a *Kalar* soil is much less than that of a soil free from these salts.

The Chemical composition of a typical *Kalar* soil of Sind is given below:

	Surface 0-6″ (%)
Total soluble salts.	2.40
Containing:	
Calcium Carbonate	0.03
Calcium Sulphate	0.62
Magnesium Sulphate	0.53
Sodium carbonate	0.01
Sodium bicarbonate	nil
Sodium sulphate	0.96
Sodium Chloride	0.43

The salts in the order of their harmfulness are as under:

1. Sodium Carbonate
2. Sodium bicarbonate
3. Magnesium Chloride
4. Sodium Sulphate
5. Sodium Chloride
6. Calcium Chloride
7. Calcium Sulphate
8. Calcium Carbonate.

NaCl produces a powdery, dusty condition; Na_2SO_4 leaves a white incrustation, while Na_2CO_3 makes the soil black and sticky (black alkali).

Soils containing $CaCl_2$ are also black but are not so bad as *Kalar* soils, containing Sodium salts.

"Sodium Carbonate, which is the most injurious salt, is rarely found in Sind. Another relieving feature of the Sind soils is the presence of an enormous amount of lime, which prevents the possibilities of the formation of sodium soil and sodium carbonate, which would otherwise result in the base exchange reactions with sodium salts", and cause deflacculation and 'pudding' of soil.

Generally, total salts, present in the soil to the extent of 0.5% or more produce a toxic effect on plants. However, "one surprising thing about the Sind salt lands is that the crops are found to tolerate comparatively high proportions of salts under Sind conditions. Many plants grow in soils with 0.5% salts".

Comparison with the Punjab soils:

The soils in Sind are lighter as we go lower down and impregnated with common salt, glauber salt and lime. Whereas the Punjab soils contain more clay and less lime, in addition to common salt and glauber salt, they contain sodium carbonate. The gradient in Sind too is less, only about 9″ per mile as compared to 12″ per mile in the Punjab. Almost all canals flow in winter in the Punjab, while in Sind, the lift system of irrigation has to be practised in the non-Barrage areas. At the same time, the river training works in the Punjab are much more elaborate; while there are no proper embankments or *bunds* built in Sind and floods are frequent. The river and canal currents have to be properly controlled.

SOIL FERTILITY

K_2O_1 P_2O_5 AND $CaCO_3$

Contents of Soils of Sind.

1

Total and Available K_2O and P_2O_3, in Surface Soils of Sind.

Potash (K_2O) and phosphoric acid (P_2O_5), in half a dozen samples analysed, are a reassurance of the soil fertility of Sind. The former is in a higher proportion at Sakrand and Nabisar, and the latter at Sakrand and Karachi (Kohistan).

As a rule the Kohistan and Thar soils are poorer in fertility ingredients than the Indus alluvium.

2

$CaCO_3$ (Lime) Contents of Surface Soil.

The lime content of the soils, suitable for wheat growth, in a number of localities in the irrigated valley proper varies from about 6.83% at Shahdadkot to as much as 19.2% at Johi. In the Kohistan area, however, it rises to 28% pointing to its residual character.

The alkaline reaction (pH value ranging from 7.3 at Sakrand to 8.9 at Mirpurkhas), indicating the presence of lime, is not unfavourable. Where the pH value is less than 8.4, the soil is free from injurious salts, as in the foothills of the Khirthars, but in the Johi area both the percentages of $CaCO_3$ as well as of salts (pH value more than 8.4), are higher and, therefore, injurious to crops.

TABLE 1

K_2O, P_2O_5 and $CaCO_3$ Contents of Soils of Sind.

(1)

Total and Available K_2O, and P_2O_5 in Surface Soil

Place	Total K_2O	Available K_2O	Total P_2O_5	Available P_2O_5
Nabisar	2.04	...	0.1433	...
Sakrand	...	0.0397	...	0.0334
Karachi	2.42	...	0.21	...
Karachi	0.46	...	0.14	...

Karachi	0.33	...	0.087	...
Karachi	0.7	...	0.162	...
Dokri	...	...	...	0.0014

(From Agricultural Research Station, Sakrand)

(2)

$CaCO_3$ (Lime Content) of Surface Soil.

Place	Percentage	pH value	Remarks
1. Mirpurkhas	8.51	8.90	
2. Oderolal	7.60	...	
3. Lundo	8.26	8.70	
4. Sakrand	8.42	7.30	Indus Left Bank type.
5. Tharushah	7.56	8.50	
6. Padidan	9.15	...	
7. Shahdadkot	6.83	...	
8. Larkana	7.20	8.80	
9. Dokri	6.96	8.70	
10. Nasirabad	8.06	...	Indus Right Bank type.
11. Shorki	6.70	...	
12. Johi	19.20	7.58	
13. Karachi (Kohistan)	28.80	8.70	Kohistan Type
14. Mithi	6.34	...	Desert Type.

SOIL EROSION AND CONSERVATION

Since soil is one of the best agricultural assets of a land, it must be conserved at any cost.

In any extremely dry region, such as the Lower Indus valley, all the hills and country-sides are barren during the greater part of the year. It is only after a few showers that they are covered with grass. Due to lack of vegetation, therefore, there are great chances for the soil to be eroded by the agencies of wind, rain, solar heat etc. Decomposition of rocks and denudation of soils are extreme in such cases. Besides, flood waters

run off at a very fast rate in such barren lands and cause soil erosion. The Indus river is notorious for its periodic floods, which destroy not only cultivable fields but also entire villages and farmsteads.

Wherever patches of riverain forest exist, people recklessly destroy trees for fuel etc., and give no chance to the vegetation to prevent such floods. Primitive methods of cultivation, heavy grazing and greed for quick returns of crops also impoverish the soil. On an average, the annul loss by soil erosion is about 60 tons per acre in some parts of Sind, so that millions of tons worth crores of rupees are eroded. Even fertile land becomes uncultivable because of the loss of its top soil in this manner.

To stop this menace in Sind some programme of soil conservation is necessary e.g., Command of the catchment areas of rivers and streams, afforestation, pasturage, care of existing forests and silviculture, reclamation of *Kalar* soils, drainage of water-logging weeds etc., are some of the means of soil conservation, which can be practised in Sind with advantage.

CHAPTER VI

NATURAL VEGETATION AND ANIMAL LIFE

The effects of climate on soils in Sind have been already noticed. On the other hand, the soils also affect the climate to some extent. Sands are heated quickly, and also cool quickly. Dry and porous sand layers suffer more because of lack of moisture. Therefore, the sun's rays, heating the sand, make the day more hot, while at night the heat is very rapidly radiated in the dry air and makes the night cold, so much so that water freezes. Hot winds blow causing sand and dust storms, and as the diurnal monthly and annual ranges of temperature are great, only plants which can stand such a climate survive.

I. NATURAL VEGETATION.

Lying in the path of the two monsoons and yet missing the benefits of both, on the border-land of the tropical and the extra-tropical regions, Sind has a vegetation peculiar to its soil and largely indicative of its hot and dry climate. Tropical fruits and grains grow in summer; but in winter, which is a bracing season, extra-tropical grains and vegetables thrive. Here the date-tree first begins to ripen from the equator northwards, the balsam family starts yielding gum resin (Cummiphora) useful in medicine and art, the apple produces an eatable fruit, and the pomegranate blossoms for the first time. Among other fruits are dates, mangoes, oranges, peaches, plums and melons. Thus it is a stage intermediate between tropical India and temperate Iran. The desert type of vegetation with the prominent plants being (1) *Phog*

Bhui (Bhusa), (3) *Lana* and (4) Mart, still persists. They are low and herbaceous plants with small or no leaves of the cactus (Euphorbia nereifolia) kind of the arid parts, while trees such as the sal and the long-leaved pine thrive in the western plains. Along the banks and sides of the Indus and the canals and far inland in *Shikargahs*, etc., forests of *Babul* (Acacia Arabica) and tamarisk, white poplar etc., are in bloom. Within the areas periodically inundated and yet not cultivated, there are impenetrable thickets of *Kandi* (prosopis spicigera), mimosa and tamarisk, white poplar and rank (Kaub) grasses. The sandhills of the desert yield enough fodder and other bushy growth varying in character, with the amount of salt in the soil, for camels and cattle that happen to live there, while the creeks and swampy parts of the delta are overgrown with deep mangroves, rhizophora, avicennia, ceriops, elephant grass etc. The plains flooded by the Indus water are covered with grass, but desert areas, such as the *Pat*, support only scattered bushes of *lana* (anabasis multiflora) etc. The hills of Kohistan, as well as the Khirthar ranges are invariably barren, though sheep and cattle do find grassy patches here and there in the valleys. The wild olive (olea ferruginea), *Lohiro* (Tecoma undulata), thorny *ber*, Farah (mannor hops vitchicana) crown some of the mountain tops. The well known elephant grass is found generally in certain localities. Lastly, the indigenous cotton and the indigenous palm are the two prominent North African plants growing in Sind.

Plant Habitat: Plants grow under certain conditions of moisture, temperature, soil conditions etc. At the same time, they are capable of adapting themselves to the environment. If their roots are unable to supply enough water to keep pace with transpiration, there is a physiological drought.

This lack of water in the soil is caused by: (1) high temperature, bright sunlight and dry winds, (2) chilly weather in winter, whereby plants are unable to absorb moisture and as transpiration

is limited, the leaves drop off, and (3) presence of salts, organic acids, etc., whereby the absorption of water is made difficult for plants. Therefore, terophyles or drought plants are possible in this region with their leaves succulent, fleshy, leathery or hairy. As the dry season recurs regularly and with great intensity trees are scarce, but grasses can grow. Herbs are active only during the moist season, and then their seeds remain, if they are capable of withstanding the drought.

Peculiarities of Sind Flora: Thus, though the flora of Sind is, on the whole, poor, it includes a number of species of plants which are not commonly met with in other parts of the subcontinent. On the contrary they have an affinity with the Arabian, Iranian or Nubian (Africa) types, since the climates of these countries and their soils are similar, viz., intense summer heat, scanty rainfall, great winter cold, dry soil and geological formations, and within practically the same latitudes.

Earlier Researches into Sind Flora: The following summary of natural vegetation in Sind has been made by Hooker and Thompson from the earlier works of Major Griffiths, Major Viccary and Dr. Stocks, showing that the Sind soil and climate are suitable for those plants which grow well in Africa, Arabia, Persia etc., and which to some extent are confined to these dry regions. In this respect Sind differs from the rest of the subcontinent.

"More than nine-tenths of the Sind Vegetation consists of plants, which are indigenous in Africa, the desert regions assimilating with the country, and owing to the remarkable identity of soil and climate with those countries, Nubian, Persian, Egyptian and South Arabian plants also occur largely in the flora. At least one half are common Nubian or Egyptian plants, which being indifferent to moisture are also found distributed in various parts of India, where the climate is suitable. As examples may be mentioned Gynandropsis, Pentaphylla, Abutilon indicum, Tribulus terrestries, Tephrosia

prupurea, Glinus totides, Ganges Madraspatang, Trichodesma indicum, Lippia nodiflora, Salanum Jacqinii, Aerua tenata, Achyranthes aspera, and others. A smaller but still considerable number is common to tropical Africa. Among these are found many Convolvulacea, and some of the commonest Indian weeds, such as Peritrophe bicaliculata and several species of Corchorus and Triumfetta. Again, about one-sixth of the whole consists of common Egyptian plants, which are too intolerant of moisture to withstand the climate of the more humid parts of India, but which extend along the Arabian and Persian coasts to Sind and thence to the Punjab and the drier parts of the Gangetic plain, and some even to the Deccan and Mysore, e.g., Peganum barmala, Cocculus leogba, Capparis aphylla, Alhagi maurorum, Fagomia arabica, Prosophis spicigera, Calotrophis provera and others, which extend to the drier parts of the Peninsula, and Malcolmia africana, Corchoprus depressus, Cucumis colocynthis, Berthelotia laucealata, Heliotropium undulateem, several species of Salvia and Chenopods which are confined to. Northern India. With these occur also a few Central European plants, such as Ranunculus exceleratus, Convolvulus arvensis, Heliotropium Europeum, Rumex obrusifolius and Potamageton pectinatum. Besides these, Sind contains a considerable number of species, which have not been met with elsewhere in India but which are Arabian or Nubian plants: such are Zygophylum simplex at album, Nourada procumbens, Azoon canariense, Trichodesma Africanum, several Barleria, Balsamodendron and Acanthedium hirtum. Puneria coagulans is confined to Sind and the neighbouring province of Baluchistan. Eastern species, which find their western limit in Sind, are almost entirely wanting. The following are all that are contained in Dr. Stock's catalogue,. excluding plants manifestly cultivated (such as Tamarindus): Rhusmyx, mysorenisis, Zizyphus jujuba, Hedyotis aspera, Coldenia procumbens, Salvia plebeia, Clerodendron phlomiodes, Aristolachia bracteata and Zeuxine sulcata."

Dr. J.E. Stocks, Conservator of Forests, Bombay presidency, recognised some 88 kinds of vegetable productions as under:

Grain (Graminea)	10	kinds
Pulses (Leguminosae)	7	,,
Oil seeds	6	,,
Greens and Vegetables	11	,,
Gourds (Cucurbitaceae)	10	,,
Dye plants	6	,,
Cordage and Clothing	3	,,
Tobacco and sugar	2	,,
Intoxicating plants	3	,,
Medicines	4	,,
Condiments	5	,,
Fruits	21	,,

So, on the whole, "over the region, a low chiefly herbaceous vegetation of plants common to most parts of India mixed with Oriental, African and European types, is spread with thickets of shrubs and a few trees. With a few exceptions most have deciduous leaves". This affinity of the natural vegetation of Sind with that of neighbouring regions is an indication that what grows in them can be grown with success in Sind. This cannot be said of any other province in the subcontinent.

Vegetation Belt: The Province can be geographically divided into six vegetation belts, which correspond in general to the physiographic divisions already made.

Name of Belt	Characteristic growth	Area covered
1. Forest	*Babul*, tamarisk, *Kandi Tali*, etc. Thorn Forest.	Banks of the Indus and E. Nara.
2. Grassland (cultivated land)	These are scarce. Grasses of diffirent types grow.	(a) Between the Indus and the western Highlands. (b) Between the Indus and the desert.

3. Mangrove swamp	Mangroves, sea weeds etc.	Delta proper.
4. Scrub land and desert	Thorny shrubs and plants acacia and cactus, bushy growth. Scrub land gradually passes into Desert.	(a) Between the E.-Nara and the E. boundary (Thar desert) (b) Between the Upper Sind and Jacobabad Dist. The *Pat.*
5. Barren land	Devoid of any vegetation.	(a) Parts of Kohistan (b) Western Highlands
6. Steep land	Scanty grass	Parts of Kohistan.

1. Forest: Nearly 1,150 sq. miles of land are covered by this belt. This is not a monsoon of temperate forest; the rainfall is insufficient for such a growth. It consists of narrow strips of land 1/4 -2 miles by 2-3 miles, submerged about 6 feet during the inundation along the banks of the Indus from Ghotki to within 30 miles of its north, numbering nearly 100 on both the banks, e.g., Mari Khanot, Laikpur (largest), Hatri (Hyderabad Dist.), Saduja, Andaldal, Shahpur (Shikarpur Dist.), Unarpur, Viran and Buto (Karachi Dist.). Another forest belt lies within the valley of the E. Nara, about 2.3 miles in breadth in the Rohri and Khairpur territories. These are riverain or inundation forests, depending upon the flood water of the river for their sustenance and growth. Floods often play havoc with *bunds* within whose limits the trees grow well.

As there are extremes of climate and irregular water supply, only hardy trees of the scrub forest type and belonging to very few species grow in these forests, e.g.,

(i) *Babul* (Acacia Arabica) - good for fuel, timber and ship building. Very tough and heavy wood. Staple tree for Lower Sind.

(ii) Tamarisk (Tamarix gallica and dioica) - very fair tree.

Used for fuel for steamers and wood for agricultural implements.

(iii) *Kandi* (Prosopis spicigera) - good for fuel, has a straight growth.

(iv) *Tali* or *Sissu* (Dalbergia Sissoo) - good for timber.

(v) *Bahan* (Populus Euphratica) - good for rafters, match wood, etc. Light tough wood.

Among other minor trees are *Nim*, *Pipal*, *Kirir*, *Ber* and *Siras*. These forests in Sind serve a double purpose - they supply timber, firewood etc., and also protect cultivable fields from being destroyed by the river floods.

A whole scheme of afforestation, following on the Sukkur Barrage scheme, has been adumbrated by Government to meet needs of the people for forest products, such as timber, *lac*, fuel, etc. The possibility has also been contemplated of planting some of the Punjab varieties of trees, e.g., mulberry for sports goods.

2. *Grass land* (Cultivated land): This plain is now largely occupied by the area under irrigation and cultivation. As the system is completed, more and more land will be cultivated and the prosperity of Sind will be greatly increased. This region is also affected by the periodical inundations of the Indus and occasional floods. Some parts of the grass-land, which are not cultivated, remain pastoral and abound in trees, shrubs, etc., useful to camels and goats. Trees, such as *Babul*, *Ber* and *Khabar* which grow best on *Kalar* soil are useful to camels. Fodder grasses are also numerous e.g., *Chhabar*, *Hariali*, Karachi *Lucerne* and guinea grass are cultivated in this belt.

This belt is interesting from the point of a variety of weeds, which grow in particular type of soils and under certain conditions. A weed survey of Sind is therefore extremely desirable, as it would help agricultural research in crops.

3. *Mangrove Swamp:* A large part of the deltaic land remains wet and muddy and is, therefore, covered with mangroves,

having their roots moistened with salt water at every high tide.

4. *Scrub-land and desert*: As there is some rainfall, though irregular in this area, it is not entirely devoid of vegetation. There is a bushy growth of rank vegetation having spines or thorns to protect themselves from animals. The plants have their roots several feet deep to suck water, and their stems are fleshy to enable them to store water in them for a long time. Eastwards toward the desert proper, vegetation of this kind also gradually disappears except on the banks of the *Dhands* or salt lakes. Tangles of lotus floating plants are a novel feature in them. Roots of these are edible and taste like potatoes.

5. *Barren land:* There is a little rainfall occasionally on the rocky parts of Kohistan of the Khirthars, but as there is no soil of any kind gathered, no plants grow and the rocks lie entirely barren. The landscape is clear and well-marked by this barrenness.

6. *Steppe land:* In parts of the Lower Kohistan region, there is some rainfall and scanty soil, allowing the growth of grass.

Ecology of Sind: Thus the conditions of the surface soil, sub-soil and water table greatly influence and control the growth and adaptability of natural flora in Sind e.g., trees, shrubs, plants and weeds, which serve *in situ* as a very useful and accurate index of present soil quality and future possible agricultural development.

A classification survey of such natural flora on the basis of their ecology, with reference to physico-chemical conditions of (1) surface soil; (2) sub-soil viz., soil texture and quality - good sevent land and *Kalar* land; and (3) sub-soil water, water level and quality, carried out systematically and scientifically should enable cultivators to assess and predict the quality of land, soil behaviour and crop performance with fair accuracy.

A preliminary survey made by Dr. Mulay in this connection revealed the following facts:

"In Sind, plants of Egypt, Persia, Southern Arabia, the Punjab and the Deccan are found. The physiognomy of the majority of Sind flora is like that of tropical Africa. There are Arabian plants in Sind such as Zygophyllum album, Seddera latifolia, Acanthodium hirtum, etc." Others are classified as:

(a) Forest Trees: (1) Different species of Tamarix: (2) Albezia lebee, (3) Cordia latifalia;

(b) Plants confined to uncultivated localities: (1) Dodnea burmannia, (2) Ziziplus, (3) Capperies aplylla, (4) Salvadoras, (5) Tecoma undulata;

(c) Grasses: (1) Andopagon annulatus, (2) Dactyloctenium aegyptiacum, (3) Poa annua;

(d) Cereals: (1) Wheat, (2) Barley, (3) Rice;

(e) Desert Plants: Two or three different species of gymnospermous ephedra;

(f) Palms: Sind is devoid of varieties in Palms except Phoenix dactilifera - a Date which grows more or less spontaneously;

(g) Plants near Sea: (1) Tribulus, (2) Aeura, (3) Species salanum of Sida, (4) Abutilon;

(h) Plants in stony places: (1) Cheuopodium Vulgare, (2) Amarautus, (3) Sueada;

(i) Plants more inside Sea: (1) Souneratia relizophora, (2) ceriops, (3) Aegiceras;

(j) Rocky Sea Plants: (1) Phaeophyceai, (2) Rhadophyceae, (3) Chloraphyceae, (4) Ulva, (5) Fucus serratus, (6) Padina, (7) Choudrus saragassum;

(k) Fresh water plants (Algae) : (1) Oscillaria, (2) Oedogoneum, (3) Phormiduem, (4) Spirogyra.

The plants of Sind which are of economic importance are of course cereals. The woods of acacia arabica, Delbergea Sisso, Acacia faruesiana, Alberzia lebbek and Populus exphratica are of some service.

Medicinal Plants: In some parts of Sind, especially on low hills of Kohistan, a number of plants of great medicinal properties grow well. The following are some of the typical ones:

Name of Plant	Medically used for
Mameccha (Stenogtia Orientalis)	Fever
Kirbet (Guitandi-na bondus)	Fever
Nuro, Nuree, Kalmeer (Grantia)	Disorders from heat
Dhurrar, Googul, Suray	Disorders from cold
Sakun (Tamarix orientalis)	Distorders of the gall
Saupat (Anertinum glacum)	Nose bleeding
Aderay-jo-denay (salanum jacquinii)	Cough
Zamir (cocculus villosus)	Head pains
Chawn (cassia absus)	Eye inflammation
Gigantic Swallow wolf (Calotropis gigenta)	Cough, Asthma
Wild egg plant (Salanum jacquinii)	Cough, pneumonia, fever
Tooth Brush Tree(Soladera persica)	Fever, rheumatism, Asthma
Salai tru (Balsamodendrou)	Inflammation
Thorn apple (Dhatura alba)	Poison
Goat foot creeper	Boils, swellings
Babul (Acacia)	Cough etc.

Other Prominent Plants. The following table shows the peculiarities and uses of certain other prominent plants of Sind:

	Kind of Plant	Peculiarity and uses of product.
Seaweeds	Manora rocks, etc.	Used in scrofulous cases.
	The broad, Green Laver	Contains gelatinous

		matter used in Scrofula.
	Sea sil 'Las' or 'Lush'	Used in manufacrure of iodine.
	Bladdery Sea-wrack	Used for jellies.
	Irish Moss or Carrageen common mushroom	Vegetable.
Ferns	Common Rice *Sari*	Contains starch.
	Creeping Cynodon	Pasture for cattle.
	Harrialee	Root used for Sarasparilla.
	Sary 10-12 ft. high	Used for making ropes.
	Elephant grass *Pun*	Holds banks of rivers or canals. Used for ropes, baskets.
Palms	Date palm perfect in Sind (about Khairpur and Sukkur), yields fruit	Used for making various articles.
	Sufaida "*Bahan*"	Used as timber and for lacquerred boxes.
Exogen	Banyan or Indian fig tree	Giving shelter.
	Poplar (*Pipur*)	Used for timber.
	Castor oil plant (Common in Thar Parkar)	Used for oil.
	Tamarisk (in jungles)	Firewood.
	Mallow 'Bunpat'	Fibre used for rope.
	Hornbeam-leaved Sida.	Used as a drug for intermittent fever.
	Alia (on lower hills)	Good for hedges.
	Indian or Egyptian Lotus (about Manchar lake)	Tubers used as food.
	Garden poppy (in irrigated soil)	Opium.
	Lycium - 'Ophthalmic	Remedy for ophthalmic

Berbery, (an exported article of Barbarike)	diseases.
Common grape	Raisins and currants.
Gum resin (rocky ground)	Frankincense and Myrrh.
Ash leaved Bead tree -*Neem*	Bark, etc., as astringent.
Fagonia 'Dhymya'	Drug for fever.
Rhubarb.	Purging property.
Indigo *(Nir)*	Used as a dye.
Sissoo (Upper Sind) *Tali*	Timber.
Common Tamarind	Medicinal value.
Acacia 'Babool' forest	Gum, lac, etc.
Dhatura	Medicinal use as narcotic
Lycium *(Gango)*	Fruits eaten by peasants, beasts, etc.
Lussora Cordia	Fruits eaten by peasants.
Convolvulua	Ropes made of fibre.
Elephant 'Creeper'	Used in cutaneous affections.
Mustard tree (Khabar) (Lower Sind)	A stimulant.
Rutunjote	Cooling plant.
Sweet Basil *(Nazboo)*	-do-
Garden Lettice	Vegetable and narcotic.
Mangrove *(Chowree)*	Timber.
Kirree (Deltaic parts)	Astringent.
Pomegranate	Dyeing and tanning.
Prosopis (Kundee) (dry ground)	Furniture, firewood.
Sirris or *Suree* (in forests)	Hard and heavy wood (Girth 7-9 ft.)

Forest Products. As there are certain pecularities of vegetation in Sind, there are chances of securing certain forest products which could not be met within other parts of Pakistan. It is,

therefore, absolutely necessary to strengthen the department of forestry in our province.

II. ANIMAL LIFE.

From the point of view of fauna also Sind falls within the Desert Area of North-west India, one of the sub-regions into which geographers have divided India. The area consists of desert or semi-desert tracts, except for the parts lying within the river valley drained by it or irrigated by man, and claims affinity with the Palaeartic and not the Indo-Malayan forms of animals.

Inter relation between Natural Vegetation and Animal Life:

Sind affords a good example of climatic control also in relation to animals. As the flora of Sind is so limited its influence on the fauna is evident. Animals which are natives of a region more favoured with rainfall, moderate heat or cold, are wholly absent. Sheep live on small grass on hills of Kohistan and dry sand-hill pasture, while cattle thrive best in water lowlands, where rich, long and juicy grass is available. There being no great forests of the monsoon type, there are only a few mammals, e. g., camels, but no ferocious animals such as tigers or lions. Also, like the vegetation of Sind, some of the animals are allied to those living in extra-tropical regions. "In some respects the fauna of Sind differs widely from that of other parts of India, having members of an Indo-African character, which do not extend far to the south or east of the province, while animals peculiar to heavy forest lands are practically absent. On the other hand, owing to the remarkable similarity of climate and nearly the same average rainfall, the fauna is almost identified with that of the Punjab, N. W. Provinces, Baluchistan, the shores of the Persian Gulf, Rajputana and parts of the western presidency south of Sind."

Rats live in burrows formed in farms and fields. Jackals, hyaenas, hedgehogs are also noticeable.

73 species of Mammals live in marshes, deserts, riverain forests and hills - such as hog, deer, wild boar, gazelle etc. Among the cattle class, the milch cows of Sind are well known and are exported to other parts of the world. Bullocks are used for irrigation purposes in the interior, while buffaloes live well in the delta swamps. Cow's milk is commonly used. In the salt marshes of the Indus delta, Kohistan and also in Hyderabad district, the one-humped species of camels are the most useful beasts of burden.

Reptiles are not so numerous (only of about 11 species), the climatic conditions not being favourable.

In the desert there are not many species of venomous land snakes. Some of the most poisonous sea snakes with flat tails are found in Karachi harbour.

Crocodiles live well in the ponds at Mangho Pir and in some of the *Naras* and in the Indus river also. Gorkhur and wild ass inhabit scrub land. In the realm of entomology we find white ants, sand flies, mosquitoes and locusts very prominent.

The *aves* of which Burns recognised 121 species in 1837, are also analogous to those of the Iran plateau and Africa and even Europe. Among them are storks, geese, ducks, partridges, owls, eagles, mayflies, flamingoes; and other migrants are also found in the deltaic water channels. Ducks, storks, geese etc., are found plentiful in the Manchar lake, which is the largest fresh water lake in the subcontinent.

Myriads of wild fowl are driven into this lake by the cold northerly winds every season and are huddled together like islands. Birds are another attractive feature of the lake. Among them are found the following:-

Starling, wagtail, kingfisher, coot, lapwing,

Caspian, tern, ibis, egret, heron, desert buzzard and parrier.

III FISHERY.

The Sind coast is congenial to the geographical distribution and ecology of fish. The following factors make it one of the best fishing grounds in the Subcontinent:-

(1) The compartively shallow waters on the submarine banks, which is only five fathoms deep on an average, and which is broader than even the Bombay or Madras Coast as it forms the relics of a continental shelf, after the subsidence and part of the Indus Gorge.

(2) The delta of the Indus is a growing one, which makes the coast so shallow that at high tide it is submerged and the sea water rushes several miles inland. There are many outlets of the river, which are, practically, the inlets of the sea, producing a regular alteration of fresh and sea water.

(3) In the monsoon season, when the river is in great flood, the delta is inundated for several miles, and when the waters are withdrawn, mud-banks, lagoons and mangrove swamps are formed in many of the creeks, which are suitable as breeding grounds for fish.

(4) The silt of the river dropped into the sea near its many mouths is considerable. This extensive drainage from the land makes the water near the coast muddy and rich in minerals and therefore very suitable for the growth of sea-weeds, which supply food and shelter for the fish living in them.

(5) The cold season, particularly in these latitudes helps to keep the hot summer water cool for at least four months of the year. This combination of hot and cold currents near the Sind coast also exerts some influence on its fishery.

(6) The Indus river itself is a good fishing ground for fishing fresh water food - fish, such as *Pullah*, for which it is well-known. Barbels and Siluruses are other kinds of river fish.

Thus the Sind conditions are similar to those obtaining on

the Madras and Bengal coasts. Among the notable sea fishes are *Surmai*, *Dhotar*, prawns, Bombay-ducks, soles, pomphrets, lobsters, and crabs. Among other wild varieties of fish inhabiting the Sind coast are sharks, saw-fish, dog-fish and skates.

(7) The bed of the river is higher than the surrounding country, as the valley is an aggraded one, so that when the river is in flood twice a year, the waters run into low ground, forming shallow lakes, which, therefore, become good fishing ground.

(8) Like the Persian coast, Sind, again, is known for oysters - a variety among food fish. The pearl oyster of Sind, called placuna placcita is a precious economic product, though it is thin-shelled and only produces very small pearls, chiefly in the salt water inlets and mud banks, which are numerous on the coast. These pearls are used as a medicine for T.B. It should be noted here that this pearl industry was developed in the early British period and also by the Meers of Sind. It has been greatly neglected now and needs exploiting.

On the whole, therefore, Sind presents a good gathering ground for fish and awaits development at the hands of the Government. So far very little has been done. In such a dry land, the importance of the fishes, enumerated above, cannot be over-estimated, as they contain all the essential elements of nutrition in an easily digestible form. For agricultural purposes, too, fish manure would be a precious organic wealth. Fish canning, if it can be perfected here, and thus the export of fish products, are prospective industries. Shark fish oil awaits development on a large scale in Sind. But all this means careful planning on a regional basis and in accordance with the laws of hydrography.

CHAPTER VII

NATURE OF IRRIGATION.

Irrigation is the mainstay of the province of Sind. With such a peculiar type of natural vegetation, trying climatic conditions and very scanty rainfall but good soil, man has practised irrigation in Sind from times immemorial. The prosperity of the province is linked with the supply of water from the Indus, however unstable and uncontrollable the river is. Its discharge rarely falls below 22,000 cusecs, while the average is as high as 1,10,000 cusecs. Under such circumstances artificial irrigation has flourished. In fact, Sind is one of the largest canalised lands in the world. Fed by snows in the upper reaches and the monsoon rains in the lower, the river has been a blessing to all cultivators. Even the silt brought down from the whole region has been enriching the soil for cultivation.

GEOLOGICAL CONSIDERATIONS

The system of irrigation in Sind is unique. It depends largely upon its geology.

(1) Sind is an aggraded valley of the Indus, the river being in its deltaic stage here, i. e., it has reached its base-level of erosion and plain stage, and the valley is filled up and grown flat, and is not a deep well-defined V-shaped hollow. Canals, small and large, cut in such a region can, therefore, be taken in any direction. There is no need of cross drainage works, such as culverts, etc., as in the Deccan.

(2) On account of the changing nature of the river channels,

many an old bed of the river has been deserted and left dry. These *dhoroes* were utilised for cultivation or as parts of new canals. Some large canals have an elongated and winding course like that of a river, e. g., the Fuleli.

(3) The gradient of the country is low, 7″ to 12″ in a mile. Therefore, the canals can be carried to any length, e. g., the Rohri canal is 205 miles in length. Such long canals are an impossibility in the Deccan, where the gradient is high and varied.

(4) The bed of the river is here higher than the surrounding country. The river is actually flowing on an elevated ridge formed by itself. There is, therefore, a great danger of floods in the country, destroying life and property. Even river *bunds* are breached occasionally during the rainy season, and the Public Works Department has to exercise great vigilance.

(5) The limestones and calcareous sandstones of the sedimentary rock system in Sind are soft, allowing a good deal of erosion and silt to form and run into the canals.

(6) The sea-shore is low, the rocks are marine and charged with connate saline material, and salt and sand are carried from the sea inland. Parts of the Indus valley, especially such as the various low level salt lakes and *dhunds* are, originally belonged to the jeskys sea bottom. Consequently there are salt deposits in many places, and the soil, too, is salty, due to extraction of soluble salts from the younger Tertiary rock system.

(7) Due to the double nature of the Indus flood levels i. e., rising in the early summer owing to the melting of the snows in the Himalayas and again in the monsoon season due to rains, inundation becomes intermittent and irregular. In Sind itself the rainfall is meagre but there are possibilities of cyclonic storms in both seasons and floods follow snow melting in summer. With such a river drainage and in a valley with such

deep alluvium and unsuitable catchment area, a dam is an impossibility, as it would not only be very expensive but constantly liable to damage. There are no smaller streams in the dry parts to be dammed and converted into tanks as in the Madras region. If a regulator or barrage were built and gates could be wholly shut or opened out whenever necessary, it would be safe. Prior to the building of the Barrage only Kharif crops could be raised with the help of inundation canals, while the bulk of the Rabi crops raised was *bosi*, i. e., crop raised by flooding land before sowing the seed and not watering it again.

(8) In the Indus valley, there is a network of sand belts and clay belts. Therefore canals passing through sand belts cause seepage and water logging, especially when their level is higher than the country, which is not the case in the system of irrigation in the Deccan. Such canals in Sind would require expensive lining, but it is a moot point whether it would be economical and successful.

(9) After the opening of the Barrage, the system of irrigation has been changed into a perennial one only within the Barrage Zone, while in parts of Upper Sind and Lower Sind the old inundation system is still in vogue. Due to the low fall of the river, the problem of water supply in Lower Sind· subsequent to the Barrage, has become very acute even in the Kharif Season, and a second Barrage would be a necessity in this locality as well, though its financial success is doubtful.

HISTORY OF ANCIENT IRRIGATION.

Few records have been preserved to indicate the details of the very ancient irrigation methods practised in Sind. The excavations of Mohenjo Daro have not been carried out over a sufficiently wide area to disclose any definite artificial water channels. However, it cannot be doubted that the people of Indus valley civilisation utilised the river water for irrigation

and cultivation of the soil, upon which their life mainly depended. In such a dry region they could grow wheat and plants such as cotton. That irrigation was also practised by the people of the Indus valley culture has been surmised by archaeologists. An inscription on one of the seals discovered states clearly that "Two canals were constructed in the mouth of Kudam (Aquarius) and Mina (Pisces) in the wood pecker (?) country". Another seal records that it took 'thirteen months to construct a canal'.

The Iranians were decidedly a people excelling in irrigation, and while they possessed the Indus Valley or immigrated into it, they would obviously endeavour to use as much river water and as much cultivable land as possible. The celebrated Persian wheel is their most useful legacy. The Arabs followed in the footsteps of the Iranians and allowed the natives to carry on with the work of cultivation, while they themselves defended and governed the land.

In the 8th. century A. D. the Arab conquerors of Sind assessed taxes on lands 1) watered from public canals and 2) watered privately by artificial means.

Nothing definite can be gathered about the system of irrigation in subsequent centuries. The only information we have been able to obtain from the history of Sind is that while at one time the land was very prosperous, at another it fell into disuse or was neglected. Even in the time of the Balooch Talpurs, the best of cultivable grounds were used as *Shikargahs* or hunting grounds. A peculiar system, called terrace-irrigation seems to have been practised in the past from a number of "Sun-drenched valleys" marked by many a relic of former irrigation. "These relics called *Gabarbasta*, often of a great size, are attributed by the Mohomedan Sindhis to infidels. They point also to shells that are formed in numbers and called them the teeth of the infidel giants. Occupation of the hills by the Hindus may have

followed upon persecution in the plains at the hands of the Mohomedan conquerors of the Valley".

But the system of irrigation was imperfect. The people took advantage of the natural high bed, which the Indus river formed by alluviation and in which it flowed, cut the heads of canals in depressions in the neighbourhood of the main stream or from the branches separated from the river itself, to avoid all flood disasters and silting, and after a short distance carried them parallel to the main stream for long distances across the low-lying areas from the marginal ridge.

Nature of the Old Canals: The Canals, on the whole, were irregular in shape, awkward in bends and were chocked up with silt from the river or from breaches of the banks. They were more natural than artificial water ways. These channels, parallel to the main river, were cut at a low gradient and waters were allowed to merge ultimately into low ground in a direction oblique to the river so as to secure as great a fall as possible. This fall varied from a foot to a few inches in a mile. They were up to a hundred feet wide and about a dozen feet deep, not enough however to draw off from the river except when in flood. They were tortuous like natural streams, a portion of the fall was destroyed owing to frequent bends, and silting was excessive. The trouble of clearing the silt was also great.

Irrigation Administration: The province was divided into districts, each under an Ameer. He generally used crude maps with lists of names of canals etc. The system of excavation of canals was also crude. They were zig-zag and carried in any direction the cultivators wished. There were no roads or inspection paths along them. During the cold season, especially from November to April, the canals were dry and so they could be cleared of silt or further excavated. The measurements as regards the length, depth and cubic contents of earth

were only rough. The unit of measure was the *Gaz*, which is equal to 27″ normally but it varied in different districts.

Irrigation before the British Conquest: Postans in his " Observations on Sind " in 1843 refers to two kinds of operations by the natives:

(1) The use of the Persian wheels by camels or bullocks;

(2) The construction of drains leading to low land.

The wheels were placed in cuts made on the banks by the river, where the fields lay close by; but whenever they were far inland, the country was intersected by canals, which frequently got chocked up. They were generally cleared by men employed by Jagirdars by means of large hoes with short handles, called *Pahoras*.

R. F. Burton has also stated in a later memoir of his:

(1) "Water was drawn off from the river indefinitely and allowed to run down the canal into some pond or marsh at the tail. Such ground was useful for growing paddy, but as the water gradually evaporated, leaving a bog of fetid black mud, thickened with decayed vegetation, and exposed to the rays of an October or November sun, a pestilential miasma was the result. Moreover, it is evident from the compound slope of the country (viz., the slope from north to south or from Sukkur to the sea, and that from the river laterly from each bank towards the inland countries) that the waters derived from the river might in many cases have been returned to it in a purified state. Thus some little would be done towards remedying the evils complained of in the Indus - shallowness and an overdeposit of silt.

(2) "The faulty shape adopted by the canals and the perseverence displayed in adhering to that form: The banks were perpendicular walls of silt or stiff clay and when undermined by the waters, they readily fell in. The excavated earth was disposed of in an immense and ever-increasing spoil bank close to the

canal, on purpose to obstruct clearance and give the workmen as much trouble as possible. No judgement was displayed in choosing a position for the head; no attention to prevent the winding of the channel.

(3) "The main trunks, as the Fulailee, Goonee and other beds, which, generally speaking, are the courses of dried up rivers, were rarely, if ever, cleaned out, on account of the expense and trouble of such works. The consequence was that in cold weather they were chocked with drifted sand, and every inundation supplied them with an additional coat of silty deposit. The effects of this neglect were severely felt at the tails of these streams. In some cases, as in the Rain river, these beds shrank into mere water courses; in others as in the Phitto, they were utterly ruined.

(4) "Under the native princes, the canal department suffered much from the curious state of misrule in which the people lived. It was not uncommon to see two or even three large watercourses running nearly parallel to each other for probably six or seven miles. The reason of this useless excavation is, that the land to the north might belong to a Rind, that to the south to a Nizamani, and the country at the tail might be Ryot land. Each family would be compelled to dig for its own water, through pride and jealousy of its neighbour; ther yots were of course left to the mercy of Government. Occasionally a Jagirdar of consequence, especially if a Baloch, would throw an embankment across a canal, when the water began to sink in order to retain it for the irrigation of his own land."

Obstacles and Difficulties: Added to these, were other difficulties and instabilities of the main river channel :-

(1) The fall of the country and the consequent tortuosity of the river as shown below :

	Direct Miles	By river	Ratio
Kashmore to Sukkur	73	109	1 to 1.49
Sukkur to Sehvan	105	169	1 to 1.61
Sehvan to Kotri	76	114	1 to 1.50
Kotri to head of delta	76	118	1 to 1.55

(2) Low and overtopping banks, ox-bow lakes and ultimate cutting out of the narrow neck of land: The result was a considerable shortening of the length of the river, excess of velocity of the current floods and considerable erosion of the banks.

(3) Deposit of silt, reduction of velocity of water and blocking up of beds: The drop of silt between Sukkur and Kotri was even greater than that between Kotri and the coast. Sandy banks and shoals are innumerable.

(4) The river banks in Sind, except at certain places, viz., Sukkur, Kotri and Jerruk, are not fixed. There was continual erosion taking place. As the heads of canals had to be cut generally through the natural banks of the river they were frequently left dry or eroded away by the powerful streams at flood times.

(5) Besides the above difficulties the question of the annual inundation of the Indus and the extent to which the country was periodically submerged by the seasonal floods required consideration. Lt. Wood, who made a special study of the problem, was of opinion that the valley was very unevenly and irregularly favoured by the waters of the river. While in some parts the inundation was general, e. g., Chandhkote, the most fertile part of Sind, in others it was partial or obstructed by the Kohistan and other hilly parts of the country e. g., Sehvan up to the head of the delta. The maximum width of floods was 20 miles in some low areas, while 12 miles was the most usual measure. On the left bank side, the breadth was not more than 3 miles due to the obstructions of the desert.

Within the delta propes, the lower portions were under

water from the tidal bore, while the upper parts were only partially inundated by the river.

Thus while some fields were fertilized, others were left barren or at the time of exceptional river floods, were destroyed by breaches in the banks or the *bananas*, small *bunds*, built by the Zamindars round their own fields.

Besides this kind of irrigation by inundation, the only parts of Sind which were cultivated independently of the Indus river and dependent on rainfall alone were: 1) Kohistan, where there was some good rainfall in certain years periodically and the cultivation chiefly was *Jowari*, sugarcane, sesamum, rapeseed, etc., 2) the Thar, where rainfall was much less and the cultivation was of *Bajri* and *Jowari* chiefly.

Early Improvement: The British were interested in the irrigation of Sind from the very beginning. In 1830 Lt. Burnes had arranged for the distribution of the Western Nara by canals. In 1851 John Jacob put up his scheme of the Begari canal and the Desert canal, while in 1859 Lt. Fife, who may be called the father of the most modern irrigation works in Sind, stated: "Sind is an alluvial plain, almost every portion of which has at some time or other been swept by the Indus or its branches. In almost every direction, traces of ancient channels are met with and where these are large and can be traced for any considerable distance, they are most useful in indicating the relative levels of the country: for it is an axiom in places like Sind, formed by the deposit from the river, that the land is always highest at the river bank and low the further the bank is receded from." He devised a cut at Rohri from the Indus to joint it with the Eastern Nara and converted this sluggish stream into a perennial canal. A year later, Fife also suggested the possibilities of these canals viz., 1) Rohri - Fuleli, 2) Sukkur -W. Nara, 3) Jerruk - Indus Right bank (to reach Keamari), 4) Jerruck - Indus Left Bank, and 5) Mithrao - Wanga Bazar.

The longest canal was the Fuleli. "Originally it was a natural branch of the Indus, which it rejoined about 16 miles below Hyderabad, but the outlet into the river was sent forward to feed other canals to the south." It was improved by the British in 1856, so that "the area irrigated by it could yield about 300,000 acres of crops every year".

Between 1884 and 1899 the works constructed and opened for public use were the Unarwah in North Sind and the Jamrao canal in East Sind.

Some of the subsidiary canals were undertaken within a short time, while others were not started until 1904-05, when the total mileage grew to 7,441, with the cultivated area increased to 29,23,929 acres out of the total available area of 95,37,670 acres.

In 1907 there were ten canal districts, created as under:-

1. Begari canal district,
2. Shikarpur canal district,
3. Ghar canal district,
4. W. Nara district,
5. Karachi canal district,
6. North Hyderabad canal district,
7. Central Hyderabad canal district,
8. Fuleli canal district,
9. Jamrao canal district,
10. N. Nara canal districts.

Improved System of Canal Construction : The canals were generally cut in such a way that they were carried away from the river bank in the direction in which the water could most easily flow and reach the fields.

Their heads were not placed on any permanent banks, but on a side channel and water was drawn off only during inundation. The heads selected for canals were very convenient. They

were based on an ancient system prevailing in the land. "The native rulers, who originally constructed most of the inundation canals in India, appear to have learnt from experience the necessity of selecting spots for the heads of the canals which were screened from the full force of the current during the inundation." The experiments made by Col. Tremendeere on silt deposits show that

(1) Those inundation canals of Sind, which draw their supplies from branches separated from the main river by islands covered with brushwood and long grass, contain a comparatively small amount of material in suspension. The brushwood and grass impede the velocity of the water and clarify it.

(2) Those canals, having their heads in the main stream, in the normal way, may be expected to contain silt to the extent of 1/300 by weight and that about one third of this quantity is ordinarily deposited in the canals.

(3) The canals, having their heads on the mainstream in a part, where the channel is restricted and the velocity increased, may contain silt to the extent of 1/200 by weight, of which half may be deposited in the canals.

These points had to be considered in selecting a site for the head of an inundation canal. Thus a favourite site was a little way above the point where the lower end of a *dhund* joins the main stream. The heads were cut in depressions or hollows, taking off from the main stream, which are dry or nearly so during the dry season, but are filled by the annual flood in the river; these are generally old courses of the parent stream which have been abandoned by the river; they are called *dhunds* in Sind and *sotas* in Bengal. "These depressions are frequently used in Sind as the sites for the heads of inundation canals; one of the arguments used in their favour is that, as they are much larger than the canals they feed, the velocity of the water is less in the *dhund* than in the canal, and consequently the silt

which would otherwise be deposited in the canal, is deposited in the *dhund* and the labour of the annual silt clearers of the canals is reduced."

But after all, the level of the canal water was all important. Even with the Persian wheel it was difficult to supply water to fields situated in the interior far from the canal banks. A water course, taken in from the canal, would supply a very limited quantity and for a very short period of time.

The system of rotational working of the canals by means of regulators, fixed across the canals of certain distances, gave some relief, as the water level could be raised to some extent thereby. But here, too, the quantity mattered much and as the velocity of water was reduced, more and more silting took place.

Construction and Preservation of Bunds: In order to protect the fields from being washed out at the time of extraoridnary floods, a system of protective *bunds* or dykes have been in existence and maintained at considerable cost. "The history of Sind irrigation is bound up with that of these *bunds*. Prior to 1869 all *bunds* in Sind were Zamindari, and they were maintained by the Zamindars themselves, but in that year the Government constructed a *bund* near the head of the Sukkur canal, this being the first Government *bund* ever constructed." Since then a number of such protective *bunds* have been built along the course of the Indus. When a *bund* is likely to break, a loop is added behind it and the land protected from total destruction. Such are the only river training works in Sind. The following are the chief:-

Right Bank	Length in miles	Left Bank	Length in miles
Kashmore Bund	73	Narch Bunds	34
Sukkur Begari Bund	46.5	Kasimpur Bunds	10.5

Ghar Canals Bunds	45.8	Small Bunds (N. Sukkur)	28.25
Nara canals Bunds	77	Naolakhi Bhorti Bund	8.92
Manjhand Bunds	5.77	Fuleli Bund	35.01
Karachi canals Bunds	56	Karachi canals Bunds	98
Total	304.05		214.68

In addition to these there are flood diversion *bunds* e. g., (1) On the left bank, protecting the Eastern Nara canal and (2) On the right bank, protecting the Manchar Aral Drainge System.

Pre-Barrage Progress: In spite of the inherent defects in the old irrigation system, the British were successful in several directions. They improved upon the inundation canal system, constructed new canals. suggested ways of occupying cultivable lands in hitherto uncultivable areas and, above all, created confidence among the Zamindars and the Haris. For nearly three quarters of a century, there was continued progress, in spite of occasional set-backs.

The following tables show the situation in 1924, which they had been able to create since 1851:-

Irrigation Work Canal system	No. of Works	Mileage in Operation Main	Branches	Cost in Rs.
Productive	28	5,677	788	3,64,94,392
Unproductive	6	950	286	70,23,448
Total	34	6,627	1,074	4,35,17,840

(2)

Sources of Irrigation	Area irrigated in thousand of acres	Percentage of Total area.
Government canals	3,080	93.7

Private canals	25	0.8
Tanks	1/3	...
Wells	43	1.3
Other sources	138	4.2
Total	3,286-1/3	100.0

There were three methods of irrigation existing before the Sukkur Barrage was opened in 1932 viz.,(1) Gravity intermittent flow irrigation (*Mok*), (2) Lift irrigation (*Charkho* or *Hurlo*) or irrigation by well-water (Larkana District mainly), and (3) Combination of lift and flow irrigation.

(1) In this, the peculiar slopes or lie of the land and the river was taken advantage of by the natives, whenever the waters in the river and canals were high enough.

"The slope of the land in a direction parallel with the river is about the same as that of the river surface; but the land also has a slope away from the river. If, therefore, a canal is cut diagonally away from the river banks and the water surface of the canals has the same slope as the river, the surface of the water in the canal will gradually become at a higher level than the land at some distance from the head of the canal. Hence the river water, which at the river qank is not high enough to flow on the land, will be sufficiently high to do so over other lower lands further inland, if carried to them in a canal. Moreover, in a large canal, the surface slope of the water may be made flatter than that in the river and hence a further gain in level, compared to that of the land, can be had for every mile the canal is carried."

This advantage of the slope or lie of the land is a great peculiarity of rivers such as the Indus, the Mississippi, etc., the river actually flowing along the top of a ridge formed by itself and not in the bottom of a deep valley. On the right bank of the Indus between Sukkur and Sehvan the gradient is still higher

than on the left and consequently some of the oldest canals in Sind exist in the Larkana district, and the flow system was closely followed.

(2) & (3). In other parts of Sind when the water level was low, water was lifted from the adjoining canals and wells by means of the Persian wheel, especially during the dry months of the year. Where the lands rose higher and higher, more than one Persian wheel were provided in turn, and, in this manner, crops of sugar-cane and other garden produce were secured in winter.

Further improvement necessary: These inundation canals, depending upon the annual flood of the river, with its characteristic fluctuations and variations in supply, were dry for nearly 8 months. Only from about the 15th. June to about the 15th. September, when the Sukkur gauge read 12 feet and more, was it possible to have a full discharge and full level of water for the field. The 18th. June was the latest day for a forecast for a fair or bad season. At the same time during the season of the swell, these canals were quite useless. Even with the head regulators a moderate level could not be maintained for all times. The waters in the winter season, though very low in level, largely ran to waste in the sea "at times 20,000 cusecs". At other times the inundation came too late when half the season was over and the water itself was too much or too little. There were losses and delays even in the lift system, which was very expensive. The supply of water was also affected by dangerous silt bars which under certain conditions formed at the mouth of each canal. Excess of water at one time, great scarcity of it at another, a Kharif season in full swing followed by another of idleness for labourers, plentiful crops in one season and starvation in another— "agriculture in Sind was more a gamble than a systematic industry."

Thus the valley was very unevenly and irregularly favoured

by the waters of inundation from the Indus. While in some parts the inundation was general, in others it was partial. Again, while some fields were fertilised, others were destroyed in the same season through breaches in the *bunds* etc. Irrigation, though independent of rainfall in Sind, thus suffered and fluctuated, as the following table shows:-

Years	Highest Sukkur reading in feet	Highest Kotri reading in feet	Area Irrigated	Rainfall.
1921	16.8	22.1	3,250,593	General and beneficial
1922	15.5	20.4	3,631,105	Scanty
1923	14.1	21.9	3,427,266	Scanty
1924	16.6	23.6	3,725,283	Heavy; and damaged early grown crops
1925	15.7	22.1	3,296,139	Average
1926	15.3	22.7	3,507,028	Above aver-rage and well distributed
1927	15.3	21.5	3,352,973	Scanty in Upper Sind
1928	14.2	19.3	3,580,764	Scanty
1929	17.7	24.1	3,805,038	Heavy and late
1930	16.9	23.1	3,247,305	Below the average; rainfell when canals full flowing
1931	13.9	19.3	3,060,051	Very poor
1932	16.7	23.7	3,497,229	Good and timely

Demands for Perennial Irrigation: The inherent defects in the methods of irrigation by means of inundation canals led to a demand for perennial irrigation. According to a report, "the cultivation at present dependent on river inundation is principally Kharif, and even this is subject to the detrimental effects of fluctuation in the river water levels; the low water supplies in the winter season can be tapped only to a small extent, and that too under very favourable conditions. Besides the liability to poor crop yields and distress from loss of harvest arising from the vicissitudes of water supply, there is a limit to the expansion of cultivation. The success of new undertakings can be purchased only at the expense of those already in operation."

(1) THE LLOYD BARRAGE (MIDDLE SIND)

History of the Barrage Project: The demand for perennial canals was continuous and some means of a certain supply of water during the whole year had to be provided.

A scheme for a solid dam was put forth as early as 1846 by Col. Walter Scott, Superintendent, Canal and Forest Department. But it was abandoned. In 1855, Lt. Fife next made a report of the irrigation requirements of Sind and devised other great canals, depending upon the natural level of the river. He was, however, doubtful whether a solid dam was possible.

The High Court of the East India Co., authorised a survey of Sind in 1857. In 1866 Col. Strachery, Inspector of Irrigation, was much impressed by the possibility and necessity, of a perennial canal system in Sind. In 1870 Col. LeMeasurier prepared the Rohri-Hyderabad canal system, which has been consolidated in the present Rohri canals, the longest of the Barrage canals.

In 1890, Lord Reay, Governor of Bombay, appointed the Joyner Committee to investigate the question of Sind Irrigation, but a couple of years later Sir Evan James recommended the

abandonment of the perennial irrigation scheme as too expensive and uncertain.

From 1901 to 1903 an Indian Irrigation Commission sat to investigate the possibilities of building a weir at Sukkur.

In 1909, Dr. Summers, Superintending Engineer, Left Bank, was convinced of the eventual need of a dam but not as an urgent necessity. The Government of Bombay then issued orders for the submission of a project for a barrage across the river at Sukkur. In 1910-12 the Government of India considered this. Then the Secretary of State appointed a Committee of experts to examine Dr. Summer's Report, but even they called the scheme "a premature project". They recommended investigation of the site proposed by the Bombay Engineers, that is, above the Sukkur gorge and not below it. The London Committee also suggested that it should be constructed on the sands. Among others, who resuscitated the project were Messers A. Hill, H. S. Beale, F. St. John Gebbie and Sir T. R. J. Wood.

In 1916 a complete scheme was submitted by the Bombay Government for a barrage with canals on both sides, and in 1918 it was seriously taken up by the then Governor Lord Lloyd. By 1920 Mr. A. A. Musto under the guidance of Mr. Beale, Chief Engineer for Irrigation, Bombay, presented the completed project for consideration by the Government of India and the Secretary of State.

At last, in 1923, the Secretary of State sanctioned the works. Construction was actually commenced on 1st July 1923, and the Lloyd Barrage, the greatest of its kind in the world, was formally opened on 13th. January, 1932. Irrigation actually commenced in June 1932. The whole scheme has cost over 20 crores of rupees.

The following were among the objects of the Barrage:

(1) To keep silt from the canal mouths;

(2) To maintain a steady flow in the canals;

(3) To enable higher duties to be realized and better yield of crops than the older canals;

(4) To convert large areas of "lift" irrigation into "flow" irrigation;

(5) To render possible the cultivation of more valuable or useful crops;

(6) To enable a larger proportion of land to be irrigated; and

(7) To provide agricultural employment fôr the population all the year round.

Location of the Barrage : The location of the Barrage was about 3 miles below the Sukkur gorge where the stream has more or less a fixed channel. Above the gorge and below this position, the course is found to fluctuate.

The Lloyd Barrage and Canal Sytsem : The following works are included in the project:

(1) A Barrage with a bridge way across the River Indus and below the gorge at Sukkur, fitted with 66 sluice gates capable of holding water up to R. I. 194.6 ft.

(2) A group of 4 canals on the left bank, including 2 Khairpur State ones :

(a) Rohri Canals,

(b) Two Feeder Canals (Khairpur State), and

(c) A new cut to the Eastern Nara.

(3) A group of 3 canals on the right bank:

(a) N. W. Canal,

(b) Central Rice Canal, and

(c) Southern or Dadu Canal.

The two groups of canals and their distributaries together are to be over 6,400 miles in length with nearly 2,000 bridges and regulators and are to irrigate some 55 lac acres of cultivated land every year. They are designed to absorb or include all the old canals within the zone.

(4) Works for rapidly draining the Manchar lake and preventing it from overflowing for a long time.

(5) Drainage and protective *bunds*, etc.

The head regulators of all the new canals are immediately above the Barrage which can completely control the river level and keep the approach to the canals clear of silt.

Thus large parts of the Upper Sind Frontier, Sukkur, Larkana, Dadu, Nasirabad (Baluchistan) on the right bank and Nawabshah, Tharparkar, Hyderabad as well as Khairpur State on the left are brought under cultivation.

Manchar-Aral Drainage System : One very important feature of the Barrage scheme is to take advantage of the presence of the Manchar Lake, for accumulating a large quantity of water in the flood season and allowing it to cover vast areas of cultivable land. The Aral then flows from the Indus inwards towards the lake. Then allowing this huge volume of water to be drained into the Indus through the Aral stream flowing backwards in the off-season, the lands get sufficiently irrigated and are in a fit condition to receive seeds for crops. The flood waters of the *Gaj* and other *Nais* are also herein diverted.

The Barrage Zone and Canal Commands : The following information regarding the Barrage Zone and Canal Commands has been obtained from the Lloyds Barrage Completion Reports, Vols, IV, V and VI :

Table showing measurements of :

Item	N. W. Canal	Rice Canal	Dadu Canal	Eastern Nara	Rohri Canal	Khairpur Feeders.	
						West	East.
1. Area Commmanded (Acres)	1,027,085	547,885	597,464	2,140,000	2,837,000	800,000	
2. Cultivable (Acres)	933,093	480,979	498,682	2,070,000	2,541,000	640,000	
3. Final Area of cultivation (Acres)	720,000	420,600	394,400	1,621,300	2,025,000	500,000	
4. Max. discharge at head (Cusecs)	5,042	10,215	2,837	13,603	10,887	1,940	2,094

5. Bed Width at head (ft.)	161.5	243	92.5	346	247	79	82
6. Length of branches (miles)	171	174	48	202.1	276		200
7. Length of main canal (miles)	36	82	131.6	512.7 (Includes Jamrao)	208	45	13
8. Length of distributaries (miles)	700.7	215	406	1,188	1,887		800
9. Length of water courses (Old and new) (miles)	8,367	6,500	2,919	9,712	20,246		

Barrage Expectation and Realization : The ultimate area of annual cultivation is 5,041,800 acres, excluding Khairpur cultivation and Naisrabad Tahsil. The following are the area and tonnage expectation of cultivation of different crops for a period of 30 years :

	Acres	Tons
Wheat	2,451,300	1,133,000
Cotton	822,200	96,000 (Lint)
Rice	682,300	447,000
Jowar and *Bajri*	635,000	271,200
Other Crops, Pulses	41,000	15,000
Oil seeds	410,000	117,000
Total acres	5,041,800	

The following table shows areas in acres and tonnage of cultivation of different crops in Sind during the year 1929-30, 1934-35 and 1939-40 for comparison with the Barrage forecast of acreage and tonnage shown above :

Crop	1934-35		1939-40	
	Acres	Tonnage	Acres	Tonnage
Wheat	1,073,331	250,643	1,268,794	316,376
Cotton	622,710	...	852,390	...
Rice	1,129,279	378,167	1,328,713	431,474
Jowar	441,084	103,645	417,424	81,460
Bajri	293,278	100,607	225,513	54,788
Other crops and pulses	508,193	...	787,390	...
Oil seeds	182,813	...	289,904	...

Comparing the acreage and tonnage of various agricultural crops in Sind as expected in the Barrage Project, it would seem that the acreage of wheat, cotton, rice and oil seeds increased satisfactorily within the short time of 8 years after the functioning of the Sukkur Barrage, but the tonnage yield of crops did not increase correspondingly according to the Barrage Project forecast calculations. For example, the area under wheat according to 1939-40 figures is only 1,268,794 acres which is about half of 2,451,300 acres of wheat which was expected according to the Barrage Project to be developed in the remaining 22 years. But the tonnage yield of wheat in the same year i. e., 1939-40 is only 316,376 which is about 1/5th of the Barrage expectation of 113,300 tons of wheat. The probable reasons for this increase in acreage and lag in tonnage yield are :

(a) Unskilled management of soils and unscientific care of crops by the illiterate *Haris* of Sind;

(b) Intensive irrigation resulting in soil deterioration;

(c) Intensive agriculture lowering soil fertility;

(d) Lack of improved strains and high yielding varieties in private farming.

Although, therefore, the increase in the acreage may be quite satisfactory, there is yet a lot to be done to increase the tonnage yield of crops fully to realize all the Barrage expectations.

On the whole the Barrage is a success, as in some parts of the province, e. g., the Eastern Nara circle, crops were doubled within the first 3-4 years. The Rabi crops of wheat and the cotton crops in the Kharif season have a marvellous growth. At the same time crops in some areas have not risen steadily due to the new conditions and local adjustments in the transition stage.

Safety of the Barrage : Except for a few weak points, now

protected by *bunds* e. g., a few on the upstream Rohri side, the Barrage is now safely lodged below the gorge. Two powerful flood seasons of 1929 and 1930 and some more recent ones have tried its stability and its safety can now be assured to the province for all time.

Hopeful conditions under the Barrage : There is no doubt that irrigation conditions have also greatly improved since the opening of the Barrage.

The report shows that the supply is satisfactory throughout the year. Even the cultivators are now getting accustomed to the new conditions. As early as 1933-34, Department of Agriculture annual report for that year said: "The great increase in the areas under both cotton and wheat during the year is evidence that advantage is being taken of the improved conditions of water supply."

Conditions on the Right Bank : The Dadu and N. W. Canals commence early in April and the Rice canal at the end of May, - a circumstance never dreamt of in the past. Not only is the Kharif irrigation supply satisfactory but "during the Rabi season it was brought under cultivation."

Conditions on the Left Bank : Here also the canals function successfully. "On the whole it may be stated with confidence that the working of the Barrage canals during the year was successful and that when the cultivators became more educated to the utilisation of early water supplies, both at the commencement of the Rabi and Kharif seasons, the full advantage of the new and improved irrigation conditions in the Barrage area will be more apparent".

Disadvantages of the Lloyd Barrage : As of old, everything in the non-Barrage Zones depends upon the period of inundation of the Indus, specially the time of the rise of the river, early or late. But the conditions in the Upper Sind area are not as

bad as in that of Lower Sind, where the period of inundation hardly comes to a month or so, and the canals are dry in Rabi season. Before the Barrage, these parts were prosperous with fertile agricultural fields, rice specially, and also good gardens. The remedies suggested are a widening of the canal control of water, distribution at the head and tail-end; but even these have proved to be of little avail during the past few years at a critical period of low inundation or heavy fluctuations of water supply. A second barrage at Kotri now built may solve this problem in Lower Sind to the satisfaction of all.

NEW PROJECTS OF IRRIGATION

The problem of irrigation in such a semi-arid zone as Sind is bound to remain perpetual owing to the very nature of the land. When the Sukkur Barrage in middle Sind was opened in 1932, the Zamindars of Lower Sind were greatly perturbed as they thought there would be very little water left in the Indus lower down for their fields, and they clamoured for another barrage somewhere within their limits. Hnd it been constructed at that time the cost would have been very low, as the equipment and machinary were still available. But the project was delayed.

A suitable location for this lower Sind Barrage was to be found. The second fixed point in the course of the Indus in Sind is near Kotri where the river rests against the hilly tract of Sind Kohistan. The foundation also could be laid on solid lime-stone rocks. At the same time, the method of construction of this barrage was to be different from that of the Sukkur Barrage for which coffer dams were made. In the case of the Kotri Barrage the engineers could choose to work on the site during the winter season when the level in the river was conveniently low. Good building stone was also available in the neighbouring hills. This barrage was opened in 1954. The third Barrage in upper Sind to be known as Gudu barrage has

now been projected.

Lower Sind (Kotri) Barrage : In the alluvial tracts of the River Indus below the areas south of Sukkur down to the sea, there were inundation canals taking off from the river which used to flow during *abkalani* season when the river levels were high. The established irrigation under these canals, of which Fuleli and Pinyari on the left and Kalri and Baghar on the right are prominent, is about 10 lakh acres. Due to increased withdrawals from the Indus and five tributries by several projects recently constructed in the Punjab, the river levels have considerably gone down. The lower Sind Barrage will give protection to this established irrigation and will also bring considerably more area under its command.

The Head works of this project are located near Kotri and on the right bank of river Indus about six miles from Hyderabad Sind. It consists of 44 hays, each of 60 clear spans, six hays to the left under sluices, 34 hays to the main barrage and 4 hays to the right under sluices. The geological conditions under the Barrage disclose continuous strands of yellow meturic hard clay overlaid by stone consisting of hard limestone and sandstones at relatively high levels. The total length of the Barrage is about 3,000 feet which is designed to pass a discharge of 8,50,000 cusecs. In addition, two head regulators are provided, one on the right, and the other on the left to feed the canals, alongwith overhead traffic bridge in pre-stressed concrete, navigation lock and fish ladder.

The total command under this project is about 27.5 lakh acres, an increase of about 17.5 lakhs acres, over the present inundation acreage. This area will be served by 3 canals on left bank and one canal on the right. The three canals on the left bank are, Fuleli (Discharge - 14,500 Cusecs), Pinyari (Discharge 19,500 Cusecs), and the lined Channel (Discharge 3,500 Cusecs). The canal on the right bank known as Kalri-Baghar, has a dis-

charge of 9,000 cusecs. Thus the total discharge from the Barrage works out to about 47,000 cusecs, which is slightly more than the combined discharges of Sukkur Barrage canals. The main crops under these canals are, Kharif crops (including rice), Sugar-cane, forest etc., the Lined Channel, serving areas in both Kharif, as well as Rabi Season.

The cultivable area lies mostly in Hyderabad and Thatta Districts, which is geologically of recent origin compared to the northern and southern parts of Sind, and hence has more salt content. It is on account of this, that a major portion of the area is rice growing.

Taking an average yield of 10 maunds per acre, the project will be able to produce six hundred thousand tons of rice having a net market value of about Rs. 300,000,000.

The total cost of the scheme, including cost of canals, is about 250,000,000.

As there are some low falls found in the course of the Kalri canal, there is also a scheme of producing hydro-electricity on this side of the river.

Upper Sind (Gudu) Barrage : Even Upper Sind needs protection from floods and from water famines now and then. The problem of irrigation in the Indus valley is such that all the resources are required to be tapped. The idea is not to allow even a drop of the Indus water to go to waste into the sea.

But in this part of the land the difficulty is that there is no fixed point in the course of the river left. The problem therefore has become doubly difficult. Besides, the alluvial tract is made of no solid foundation and only clayey parts are available. A scheme of this new barrage has, however, been prepared.

Upper Sind has been irrigated by inundation canals since the pre-British times. The prospects of assured irrigation have

however, always been precarious on account of the fluctuation of levels of the Indus. The situation has been aggravated in the last half a century due to increased withdrawals from the Indus in East and West Punjab. The Sukkur Barrage provides an assured supply of water to middle Sind, but the areas to the north of Sukkur are not served by it.

In order to provide sufficient water for northern Sind an additional barrage is considered necessary. This will now be constructed at Gudu at the northern tip of Sind. The soil is clayey and the river meanders much at the site. But as no better site is available within 100 miles the present site has been chosen with a proviso that the river will be trained. The scheme will supply water to the area during Kharif season (April-October) when the discharge in the river is sufficiently high. It will, however, not be able to cater for the Rabi season (October-April) except heavy initial flooding in the beginning of the season.

The gross area commanded by the scheme is 26,00,000 acres of which the culturable area is 22,00,000 acres. This is much more than the 9,00,000 acres of irrigated by the inundation canals at present. Thus the sceme will give an assured supply of water to more than twice the area irrigated unsatisfactorily at present. The cultivation in these areas consists principally of rice, millets, pulses and grams.

The scheme is a productive one. It is expected to yield a return of 4.2% in the 10th year and 5.4% in the 15th year after completion.

The Barrage at Gudu will consist of 55 spans of 60 feet each. One of the spans will be fitted with a lock to enable river traffic to pass from one side of the Barrage to the other. Two fish ladders will also be provided to allow fish to travel up and down the river, when the Barrage gates are closed.

It is proposed to take off two feeders from the Barrage on

the right bank and one on the left bank. The full-supply discharges of these feeders are to be 12,900, 15,500 and 8,500 cusecs respectively. These feeders will be joined to some fourteen existing canals, which will be remodelled along part of their courses.

The total cost of the scheme is estimated to be Rs. 27 crores.

CHAPTER VIII

ECONOMIC ASPECTS

(1) AGRICULTURE

Although Sind depended upon its old but defective inundation canal system centuries before the Barrage, its agriculture was considered to flourish all the conditions of good agriculture being generally fulfilled viz., water supply, soil culture, climate and labour.

In fact Sind was in the olden days, a precious granary of the world. Sind cotton and wheat were well-known even at Mohenjo Daro. During the hot summer season, only tropical grains and fruits grew well, while during the cold and bracing winter season with little rainfall again extra-tropical and European grains, vegetables and fruits throve. Thus the economic resources of the province were hybrid.

Defects of the old system : There were also many defects. The crops, in the rainless season, were wholly dependent on the strength or height of the inundations of the river. They were often washed out by high flood waters when unprotected by river embankments. In the cold season on account of a very low level of the Indus water, fields far removed from the river or main canal, could not secure a supply of water by flow method. Consequently, the crops produced in one season were nearly every time more than those in the other. Under the old system of agriculture, there was always a long interval left, between two consecutive crops, a period of two or three years

called 'Sind Fallow'. It was a diluted system of cropping, independent of any manure and so agriculture in pre-Barrage days in Sind was a simple affair.

Lt. J. G. Fife has given a very appropriate picture of Sind in 1855:-

"When the cultivator is exposed to so many risks arising from the capricious nature of the water supply, it cannot be a matter of wonder that the people should look upon cultivation as a species of lottery. They are successful one season, bankrupts the next; no one who sows can tell what he will reap. Too little or too much water, the supply coming too soon or too late, and the height arising from sowing at the wrong time, combine to render speculation on the result of the cultivation a riddle which none can solve."

Season of Cultivation. There were two seasons:-

1. Kharif. June to October (Height of inundation); seeds were sown in spring and the harvest was reaped in autumn. Rice, Juwari and cotton were cultivated as they required heat.

2. Rabi. October to March (Winter) in which wheat, barely, oil seeds, opium and tobacco were grown in certain areas only.

Products of Agriculture. Cereals:

I Rice: Most extensively grown crop in Sind. (Requiring well drained alluvial soil, solar heat, and a good water supply). Best crops of rice were grown in:

1. The Delta, (Karachi district) annualy inundated. Cooler and moister climate. Adopted to deep water conditions.

2. Larkana and Upper Sind Frontier district, watered by *Nais* and canals.

3. Hyderabad and Thar Parkar district in *Dhands.* Mostly

irrigated crops from June to September.

II Bajri and Juwari : (Grown in drier parts even without irrigation).

These were the principal food of the people and grown in Hyderabad, Nawabshah, Thar Parkar *(Bajri)*; Larkana, Sukkur and Upper Sind Frontier districts (Juwari).

III Wheat : (Requiring moderate water supply, winter crop and loamy soil, more retentive of moister.) Grown in Larkana, Upper Sind Frontier, Sukkur and Thar Parkar in *Dhands*. Intermediate between Bombay and the Punjab but superior to Bombay wheat in its soft white forms.

IV Barley Maize : (Grown in the same area as wheat).

Pulses:

Gram and *Matar* grew in Larkana, Sukkur, and Upper Sind Frontier districts.

Oil Seeds:

These were *Jambo*, Sesame and Rape. Grown in Hyderabad, Larkana and Upper Sind Frontier.

Cotton:

Grown in Hyderabad, Nawabshah and Thar Parkar districts. There are several varieties–Sind cotton (short stapled), Egyptian and American cotton (long stapled and requiring irrigation).

Best fibre crop in India–essentially Kharif. Though grown from most ancient times, it was not an extensive crop before the British conquest. Sind soil (loamy or sandy and loamy) is best suited. Before the Barrage, cotton suffered from damage by frost due to late flow canals.

Others:

Among other agricultural products were indigo, tobacco and Bombay hemp. It must be remembered that the broadcast sowing of seeds is the most common feauture of Sind Agriculture.

Vegetables: Greens, hibiscus *(bhendi)*, brinjals, gourds, melons, tomatoes, lettuce, beetroot, cauliflower, peas, chillies, mustard, guava, grape, plantain and papaya.

Stock Farming: Cattle throve well in grassy lands and alongside wheat farming e. g., milch and plough cattle and bulls are among the best in India. Buffalloes live well in the delta land and on river banks. Sheep and goats lived in scrubland, and hilly and eastern parts of the province.

Camels, asses and poultry also throve, while horses were imported from Baluchistan and Khorasan.

Mixed Farming: 'Mixed Farming' consists of the practice of both Agriculture and Dairying side by side and has great economic value for the cultivators in Sind as a secondary occupation. There is great need and scope for the developing of mixed farming in Sind since it is a source of side income. Farm fodder can be grown and fed to cattle, and solid and liquid excreta of dairy cattle can be used as compost manure or farm-yard manure for farm lands. However, illiteracy of the cultivator and the system of tenure in Sind are great handicaps to the development of Mixed Farming in Sind.

Live Stock: Red Karachi and Thar Parkar Cows have a wide reputation for adaptability to and suitability for difficult countries and clives. It is essentially and purely bred for milk and has been considered of little value as a draught animal.

Nathan Crow, Political and Commercial Agent to the East

India Co. in Sind towards the end of the 18th century, gives a somewhat exaggerated account of agriculture in the province:-

"The fertility of the country, where it is exposed to inundation is as great as that of Egypt and subject to less variety and uncertainty, the waters being regular in their return, departure and quantity, beginning to rise about the latter end of April and to subside early in September. The breadth of the swell varies according to the nature of the country, through which the river passes, in general. I believe, it is felt at least five miles from the banks on either side and in many parts much more particularly in the delta, where the land is flat and the intersections of the stream many, and in Sewistan likewise where the country is of the same description and the water courted and retained by more industry and art than is practised in other parts. Those parts of the country of Sind, which lie out of any reach of the benefits of the inundation, depend for their fertility upon the firmament which is as precarious as the river is constant.

"In the parts far removed from the river, grain is less cultivated, but they produce a very superior kind of grass and various herbage for the pasture of horses, camels and horned cattles, of which latter the number is so great that the poorest people possess enough for the support of themselves and families; but in years of drought which often occur two or three in succession, the mortality amongst these animals is very great and the distress of the lower part of the inhabitants proportionately severe."

Failure of crops and Famine: Agriculture in Sind mostly depends on irrigation, the proportion of irrigated total area being the highest in the subcontinent viz., 86%. It is therefore the least likely province in the subcontinent to suffer from famine on account of scarcity of rain.

There are however certain parts of Sind viz. Kohistan area

and the Desert region which cannot be irrigated by any means and which suffer from scarcity of food and water occasionally. The famine of 1899-1900 was the worst. Since then the seasons of 1911-12, 1915-16, 1918-19, 1930, 1938 and 1940, have been marked by failure of rains and crops especially in the desert area.

Even in the irrigated parts of Sind, crops fail resulting in a local scarcity of agricultural commodities on account of floods, crop pests like locusts migrating from Rajputana, boll worm etc., the wrecking of crops by diseases, and lastly, adverse climatic conditions e. g., strong blasts of wind, excessive heat and cold, frosts etc.

Whatever may be the value and truth of the above statement, the very fact that Sind does not depend upon rains but on irrigation for its crops, shows it that it is the least likely province in the subcontinent to suffer from famine.

Pre-Barrage Progress of Cultivation: Lt. Fife has shown in a report that the total cultivation on canals, wells, floods, etc., in 1853-54 was 9,97,303 acres. Nothing definite is recorded for other years but the average annual income on which revenue was collected was Rs. 14,00,000 for the period 1853-54 to 1863-64 and Rs. 15,00,000 for the period 1863-64 to 1873-74. Later still these were fluctuations in irrigated lands and crops. For some later years, definite figures are available:-

Area in thousands of acres

Year	Net crop	Area irrigated by canals	Percentage of Canal irrigated area to net cropped area.
1885-86	1470	1238	84.2
1895-96	2655	2009	75.7
1904-5	3357	2802	83.5
1815-16	3254	2935	90.2
1925-26	3964	2840	72.0

Thus the seasonal variations definitely affected the areas of irrigated lands and of crops during all these decades.

Irrigation and cultivation in the whole of Sind before and after the Barrage are as follows :-

Statement showing area in thousand acres of Irrigation and cultivation in each District of Sind before and after the construction of the Lloyd Barrage.

1924-25

District	Net cropped area.	Irrigated Area.	Percentage of irrigated to net cropped area.
Karachi	408	334	81.9
Hyderabad	663	663	100.0
Thar Parkar	964	391	40.6
Nawabshah	532	484	90.9
Larkana	808	586	72.5
Dadu	-	-	-
Sukkur	514	296	57.6
U.S.F.	536	533	99.4
Total (Sind)	4425	3286	74.3

1934-35

District	Net cropped area.	Irrigated Area.	Percentage of irrigated to net cropped area.
Karachi	343	321	92.2
Hyderabad	708	690	97.5

Thar Parkar	719	707	98.3
Nawabshah	628	608	96.6
Larkana	628	491	98.3
Dadu	445	396	89.0
Sukkur	475	398	88.3
U.S.F.	495	404	81.6
Total (Sind)	4618	4142	89.7

1939-40

District	Net cropped area.	Irrigated Area.	Percentage of irrigated to net cropped area.
Karachi	353	307	87.0
Hyderabad	850	834	98.1
Thar Parkar	893	867	97.0
Nawabshah	776	748	96.4
Larkana	713	524	73.5
Dadu	451	357	79.2
Sukkur	638	502	78.7
U.S.F.	616	477	77.4
Total (Sind)	5289	4616	87.3

The best districts were Hyderabad and Upper Sind Frontier, where irrigation was more or less perfect, while the poorest results were in Thar Parkar, where there was practically no irrigation by inundation.

It will be seen from the above table that the pre-Barrage percentage figure of 100% of irrigated to net cropped area in

Hyderabad District is reduced to 99.5% in 1934-35 and 98.1% in 1939-40, and in Upper Sind Frontier District, the pre-Barrage percentage figure 99.4 of irrigated to net cropped area is reduced to 81.6% in 1934-35 and 77.4% in 1939-40. It proves that in the pre-Barrage times, the Begari course in the USF District and Fuleli canal in the Hyderabad District functioned better and supplied more irrigation water than after the Llyod Barrage. Another important feature is that although the percentage of irrigated to net cropped area in the remaining districts in 1934-35 is more than that of year 1924-25, yet it has uniformly decreased in 1939-40. The only possible reasons for this reduction in the irrigated area can either be the silting of canals which has reduced their discharge capacity; or excessive withdrawals of water by the Punjab which has caused water shortage in Sind, in both the Kharif and the Rabi seasons.

This controversy was going on for long time between Sind and the Punjab, and on representation by Sind Government the Government of India referred the case to the Indus Water Commission for inquiry and report.

Pre-Barrage Conditions: How crops in Sind suffered before the Lloyd Barrage was established can be somewhat gauged from the following summary prepared from the Statistical Atlas of the Bombay Presidency (3rd Edition, 1925). Not only heavy rains and floods, but deficient inundation, absence of every occasional shower of rain, and failure of hill torrents affected the condition of agriculture now and then.

Year	Conditions of Inundation	Conditions of Crops	Remarks
1904-5	Low inundation.	Severe frosts damaged Rabi crops.	Insufficient rain in Thar Parkar

1905-6	Floods in Upper Sind.	Crops damaged by insects in USF and Nara valley, and by locusts in the desert Nawabshah.	Hail storms in Larkhana.
1906-7	River low at first and rapid next, high river and heavy rain followed Breaches.	Locusts etc., in Upper Sind, Hyderabad and Thar Parkar.	
1907-8	Inundation poor.	Crops suffered through shortage of water.	
1908-9	Flood in Karachi district destructive.	Severe frost damaged winter crops in Upper Sind and Hyderabad.	
1909-10	Deficiency of water in Upper Sind and Nawabshah, Floods in Nawabshah and Larkana.	Locusts etc., in Upper Sind and Nawabshah; Locusts, in Karachi and USF.	
1910-11	High inundation, abnormally heavy floods. Rain-fed hill torrents in Larkana. Floods also in	Rabi crops suffered from adverse winds and insufficient flooding. Slight injury by frost in Larkana,	Heavy Rainfall.

	Nawabshah and Hyderabad.	Thar Parkar and Sukkur.	
1911-12	Inundation, very unsatisfactory. Absence of rain and failure of hill torrents-Upper Sind suffered most.	Locusts in Upper Sind.	Rainfall poor.
1912-13	Late rise and early fall of the river. Floods and hill torrents.	Crops damaged in Larkana and Karachi by floods and locusts.	Rainfall heavy.
1913-14	Heavy rainfall in low lying tracts. Breaches and floods in Larkana, Hyderabad, Karachi.	Insects and adverse winds destroyed crops in USF; frost in Sukkur.	Rainfall heavy.
1914-15	High inundation and abundant rainfall, Breaches and Floods damaged Kharif Crops.	Adverse winds and insects destroyed crops in USF.	

1915-16	Inundation unusually low.	Locusts etc., in USF and Nawabshah.	Rainfall scanty.
1916-17	Floods in Larkana, Nawabshah, Hyderabad, Karachi.	Frost damaged crop in Larkana.	Rainfall heavy.
1917-18	Heavy floods.	Heavy and untimely Rain in Thar Parkar, destroyed Bajri crops.	
1918-19	Low inundation.	Insects etc., in USF.	Rainfall scanty.
1919-20	Excessive rain and floods, in Karachi, Larkana, Hyderabad.	Frost damaged crop in USF and Larkana	Rainfall heavy.
1920-21	Unfavourable inundation.	Insects etc., in Hyderabad and Karachi.	Rainfall inadequate.
1921-22	Belated rise of the river, Floods in Karachi and Larkana.	Insects etc., in Thar Parkar, Nawabshah and Hyderabad.	,,
1922-23	Floods in Larkana.	Want of grains in Thar Parkar.	,,

Canal cultivation in Sind fluctuated from year to year and from season to season, as the following data (in lakh of acres) for nearly half a century would show.

Year	Kharif	Rabi	Total	Jagir	Total
1873-74	11.96	2.23	14.19	Included in	14.19
1874-75	12.24	3.73	15.97	Kharif and Rabi figures	15.97
1875-76	11.39	2.51	13.90	1.91	15.81
1876-77	12.91	4.19	17.10	1.36	15.46
1877-78	10.94	2.02	12.96	1.23	14.19
1878-79	13.33	5.52	18.85	1.31	20.16
1879-80	11.15	2.28	13.43	1.11	14.54
1880-81	11.73	1.56	13.29	1.64	14.93
1881-82	12.60	1.59	14.19	1.83	16.02
1882-83	12.82	2.26	15.08	1.65	16.73
1883-84	11.97	1.65	13.62	1.79	15.41
1884-85	13.54	2.32	15.86	1.97	17.83
1885-86	12.89	2.44	15.33	2.07	17.40
1886-87	14.08	1.86	15.94	2.21	18.15
1887-88	14.38	2.15	10.53	2.18	18.71
1888-89	16.49	2.39	18.88	2.31	21.19
1889-90	17.22	3.88	21.10	2.40	23.50
1890-91	15.97	3.58	19.55	2.48	22.03
1891-92	15.14	4.36	19.50	2.16	21.66
1892-93	16.33	5.35	21.68	2.31	23.99
1893-94	16.68	4.72	21.40	2.46	23.86
1894-95	16.21	7.72	23.93	2.43	26.36

1895-96	15.22	3.19	18.41	2.56	20.97
1896-97	18.79	3.65	22.41	2.53	24.97
1897-98	19.95	5.30	25.25	2.81	28.06
1898-99	18.03	3.73	21.76	2.80	24.56
1899-1900	19.45	3.42	22.87	2.82	25.60
1900-01	21.68	5.45	27.13	3.31	30.44
1901-02	19.83	5.26	25.09	2.99	28.08
1902-03	19.39	3.85	23.24	3.02	26.26
1903-04	21.98	6.11	28.09	3.43	31.52
1904-05	20.90	5.24	26.14	3.10	29.24
1905-06	23.80	6.31	30.11	3.37	33.48
1906-07	23.77	7.85	31.62	3.24	34.86
1907-08	20.82	4.34	25.16	2.56	27.72
1908-09	23.61	6.68	30.29	3.16	33.45
1909-10	23.61	6.68	30.29	3.16	33.45
1910-11	22.87	5.45	28.32	2.90	31.32
1911-12	21.02	3.98	25.00	2.33	27.33
1912-13	23.34	4.40	27.74	2.65	30.39
1913-14	23.58	5.12	28.70	2.77	31.47
1914-15	23.02	7.32	30.34	3.15	33.49
1915-16	21.31	6.20	27.51	2.81	30.32
1916-17	25.29	5.86	31.15	3.13	34.28
1917-18	21.88	7.16	29.04	2.56	31.60
1918-19	18.85	3.34	22.19	1.98	24.17
1919-20	23.08	5.88	28.96	2.59	31.55
1920-21	22.21	3.05	25.26	2.37	27.62
1921-22	20.96	5.87	26.83	2.56	29.39
1922-23	22.75	6.56	29.31	2.94	32.25

1923-24	22.53	5.19	27.72	2.88	30.60
1924-25	23.85	6.35	30.20	2.92	33.12
1925-26	23.16	3.90	27.15	2.83	29.98
1926-27	23.02	5.87	28.89	2.68	31.57
1927-28	23.16	4.02	27.18	2.55	29.73
1928-29	23.95	5.07	29.02	2.69	31.71
1929-30	25.60	5.29	30.89	2.73	33.63
1930-31	23.67	6.18	29.85	2.62	32.47
1931-32	22.06	5.96	28.02	2.58	30.60

Prospects under the Lloyd Barrage: "Agriculture after the completion of the Barrage canals system is expected to be more widespread and intensive. The old basis of agriculture in Sind, namely, 'Sind Fallow' will practically disappear. On the left bank of the Indus the countryside will be converted from an essentially Kharif tract into an essentially Rabi tract. The cropping intensity will be more than doubled, thus making manure or equivalent a sine qua non of Sind agriculture. A steady supply of water throughout the year at the rate of one cusec per 370 acres of land will be provided to the agriculturists to enable them to grow 100 acres of Kharif and 200 acres of Rabi crops, leaving 70 acres fallow every year. It is designed that the increase in the intensity of Rabi crops from the present 7 % to the final 54 % will be gradual within twenty to thirty years after the opening of the Barrage canals."

Barrage Improvements: As soon as the Barrage was opened on 13th Jan., 1932, and the seven perennial canals began to operate, conditions improved considerably. The irrigated area included parts of the Upper Sind Frontier Province, Sukkur, Larkana and Dadu districts, Nasirabad Tahsil (in Baluchistan) on the right Bank and those of Nawabshah and Thar Parkar and Hyderabad districts, as well as Khairpur State on the left.

"The total area commanded by the Barrage in Sind territory is 7,406,000 acres; as of this 5,042,000 acres are expected to be cultivated when the Barrage and its canal system are fully developed and as the area cultivated within the Barrage Zone before the Barrage was 2,037,000 acres, the increase should be 3,005,000 acres."

The progress for the initial years of the Barrage is shown as under:-

	Acres of cultivation 1931-32	Acres of cultivation 1932-33	Increase or Decrease
Kharif season	2,408,604	2,478,289	+ 69,685
Rabi season	651,447	1,018,940	+ 367,493
Total	3,060,051	3,497,229	+ 437,178

The table on the opposite page shows the acres of cultivation before and after the Lloyds Barrage and increase or decrease in cultivated area in Sind.

Table showing the acres of cultivation before and after the Lloyd Barrage, and increase or decrease in cultivated area in sind :-

Season	Acres of cultivation 1932-33	Acres of cultivation 1933-34	Acres of cultivation 1934-35	Acres of cultivation 1939-40	Increase or Decrease of 1933-34 on 1932-33	Increase or decrease of 1939-40 on 1934-35	Increase or decrease of 1939-40
Kharif	2,478,289	2,469,636	2,456,246	1,878,739	−8,653	−577,507	−599,550
Rabi	1,018,940	1,848,813	1,584,347	2,944,465	+829,873	+1,360,118	+1,925,525
Total	3,497,229	4,318,449	4,040,593	4,823,204	+821,220	+ 782,611	+1,325,975

For camparison with the acres of cultivation before and after the Lloyd Barrage and the increase in cultivated area in Khairpur State the following table is given:-

	Pre-Barr- -age cultiva- tion (Average) 1925-26 to 1931-32	Acres of cultiva- tion in 1934-35	Acres of cultiva- tion in 1938-39	Increase of 1934-35 over Pre- Barrage cultivation	Increase of 1938-39 over 1934-35	Increase of 1938-39 over Pre- Barrage cultivation
Kharif	1,24,432	134,309	176,021	+9,877	+41,712	+51,589
Rabi	63,846	125,202	161,551	+61,356	+36,349	+97,705
Total	1,88,278	259,511	345,572	+71,233	+86,061	+157,294

It will therefore be seen from the above that in Sind, Kharif cultivation decreased and Rabi cultivation has increased; whereas in the Khairpur State both Kharif and Rabi cultivations increased, since the functioning of the perennial Irrigation Canals System in the Province.

New Barrage Area : While such is the happy state of affairs within the Barrage Zones, parts of Upper Sind and Lower Sind lie outside the Barrage Zone and its influence, and therefore, they were undergoing hardships. As the inundation is at times poor and low and the river as usual rises late in June and falls as early as September, the crops in Lower Sind are particularly affected. The damage due to floods is also great. There was therefore an imperative need of a canal in Lower Sind to irrigate and cultivate vast areas of land lying in the Karachi and Thar Parkar Districts. Although later Nihchal Wah, Vazirani Wah and another Wah were proposed for Tatta Division and Sano, Sujawal and Shorki areas, there was the necessity of

a Second Barrage across the River Indus, which has now been constructed near Kotri to store water and raise the full water Supply level for Kharif and Rabi cultivation in lower Sind, instead of allowing surplus water to go waste into the sea. Since the Karachi Municipal Corporation was preparing a scheme for water supply for Karachi by taking water from the River Indus at Kotri or Jherruck, it was obviously economical and sufficient for both the Lower Barrage and Karachi water supply schemes to be combined and co-ordinated to solve the problem of water supply for Karachi and irrigation for Lower Sind once and for all.

Redistribution of Crops under the new regime: The new system of perennial irrigation in the Barrage area has caused a certain amount of re-distribution of crops and their improvement by the Agricultural Department. Rice, Jowar, Bajri and Wheat among the cereals and cotton among the fibres and oil seeds are the most important crops of Sind.

Cotton: Sind is the only Province in the sub-continent which may be said to be suited for the production of long staple quality cottons of Egyptian Sea Island types. Following table would show the increase of American Cotton production in Sind during 1934-39:-

Year	Area in Acres.			Percentage of
	Desi	American	Total	American cotton
Pre Barrage decade	-	-	3,20,880	8.0
1934-35	4,82,561	1,40,149	6,22,710	31.1
1938-39	2,74,071	5,81,781	8,55,852	67.9

Of the total area of 854,390 acres under cotton in 1939-40, 44% lies in Thar Parkar, 26% in Hyderabad and 24% in Nawabshah Districts.

Cotton is a tropical and sub-tropical crop and being deep rooted, requires deep well-drained soil, and retention of moisture. It requires less sun and more moisture in the vegetation stage and more sun and less moisture in the friting stage. It abhors rain at the picking stage and continued frosts kill it. From the point of view of climate and soil, Lower Sind is suitable for cotton, which accounts for 94% of the cotton cultivation in Nawabshah, Hyderabad and Thar Parkar district. The cotton yield in lbs per acre is 222 (cleaned) according to average figures of 1934-37.

After a special study af climatic and agricultural conditions prevailing in various cotton tracts of Sind, it has been proved unequivocally that Sind is the best cotton growing tract in the subcontinent for long stapled cotton in general and American cotton in particular.

The improved strains given on the next page have been evolved to suite the various cotton tracts of Sind:-

improved strains evolved to suite the various cotton tiacts in Sind :-

Variety	Staple length	Counts spun	Ginning out-turn	Yield	Tract for which it is suitable
1. Sind Sea Island and Sind Egyptian	Very long 1-1/4″ - 1-1/2″	70-80	32%	Half the Sind American	Special areas of east Sind
2. Sind Sudhar (Sind American)	Long 15/16″-1″	40	30%	High	Thar Parkar and part of Hyderabad
3. Sind 4F-98 (Sind American)	Medium long 7/8″-1″	34	33%	High	Dadu, Larkana, Sukkur, part of East Sind and Thar Parkar
4. Sindhi Desi	Short rough and Bright 1/2″-5/8″	6-8	38%	Very High	Nawabshah and part of Hyderabad District.

Cotton suffers from diseases like Red Leaf and Root Rot. Red Leaf disease can be reduced greatly by sowing seeds of the right variety in the right season and by correcting nitrogen deficiency in the soil. Experiments for combating Root Rot are still in progress at Government Agriculturing Farms in Sind.

Cotton is susceptible to pests like pink boll worm and spotted boll worm. To kill the former the cotton seed is subjected to sunshine and dried completely, and in order to eradicate the later, cotton stalks are cut from ground after the crop has been picked.

The total area during the year 1941-42 under cotton in Sind including the Khairpur State, was as under:-

1.	Hyderabad	2,04,481	2,23,900	2,36,962
2.	Thar Parkar	3,76,466	3,85,713	3,91,212
3.	Nawabshah	1,96,730	2,22,397	2,17,375
4.	Other Distts.	18,134	81,632	86,463
5.	Total (Sind)	7,95,809	9,13,642	9,32,012
	Khairpur State	5,002	60,563	58,780
7.	Grand total	8,45,811	9,74,205	9,90,972

Out of the total area of 9,32,012 acres of cotton in Sind about 6,77,943 acres viz. 73% are under American varieties and 254,069 acres viz. 27% under Desi. In Khairpur State, out of 58,780 acres, about 20,340 acres viz. 35% are under American Cotton and 38,440 acres viz., 65% under Desi Cotton.

Cotton is mainly a dry region cash crop and grows very well in some parts of Sind. The soil being sandy, silty and deep, irrigation water runs off easily and the air needed for its growth can enter the inner layers. The cotton is now the best grown in the sub-continent.

In 1933-34 Kharif cotton was cultivated on 4,86,000 acres against the average of 3,15,500 acres in the previous ten years.

The area may expand to 1,000,000 acres, spreading over the following districts: Dadu district, (Kharif) in which cotton was non-existent before the Barrage and Thar Parkar district (Kharif). More and more other crops, such as rice, are replaced by cotton within the Barrage Zone.

Wheat :

Year	Area under cultivation	
1931-32 (Pre-Barrage)	4,69,117	acres
1934-35	10,74,400	,,
1939-40	22,68,794	,,

Wheat is the most important Rabi crop of Sind. It requires retentive soil and a fairly cold climate for growth and a warm dry climate at the time of harvest. 1/3 of the total area under wheat lies in the Thar Parkar and Nawabshah Districts. Since the introduction of perennial irrigation under the Llyod Barrage Scheme wheat cultivation has considerably extended. The average yield of wheat per acre works out to be 800 lbs according to the figures for the year 1934-35.

The best period of sowing wheat in Sind is November during which it can be grown profitably. If sown earlier it is liable to frost attack; sown later, there is a danger of rust disease and immaturity of the grain.

There is a great need for high yielding varieties of wheat, resistant to rust (rate) disease. In North Sind under irrigated conditions, C. Pb, 47 and AT 38 have proved high yielding varieties, whereas in Hyderabad Division, Punjab 8-A gives the highest yield, and under *bosi* (without cold season irrigation) conditions AT 38 and C.Pb. 47 are doing very well. Some hybrids

between improved Sind varieties and Pusa 12 i. e. AT 38 x Pusa 12 (No. 139) and C Pb 47 x Pusa 12 (No. 37) have been found to be promising both in yield and grain quality for Upper Sind.

The wheat crop is prone to rust disease and sensitive to frost attacks.

Rice

Year	Area under cultivation.
1931-32	1,182,963 acres
1934-35	1,129,279 ,,
1939-40	1,328,713 ,,

Rice is a tropical crop growing in water under anaerabic conditions. Rice was mainly grown in Larkana and Karachi districts in the Pre-Barrage times. Subsequently rice cultivation has been extended to Dadu, Hyderabad, Sukkur and USF Districts. According to the average figures for the years 1934-37, the rice yield is about 800 to 1200 lbs (husked) per acre according to variety. The main problem of the Barrage area therefore is to evolve high yielding varieties of rice, while in the non-Barrage areas the problem is to select early maturing varieties on account of shortage of irrigation water.

Kangni 27, *Jajri* 77, *Prong* 37, and hybrid strains, Silver Jubilee 34-267-51, and Kangni x Torb cross 16-1-28 are becoming popular in the Barrage canals area. In north Sind under inundation canal areas, *Kangni* 27, and Bengal No. 1 area being encouraged, whereas in Lower Sind, new type 'y' and improved strains of *Ratrya* and *Motya* in Fuleli canals area, *Kangni* 27, *Jajri* 27 and the Hybrid strain 34-267-51 in the Karachi district, have been introduced.

Brown Spot (i. e. leaf spot or blotch) disease of rice locally known as '*rati*' is a common rice disease in rice tracts. This disease reduces the yield of paddy by 25-30% and impairs the

quality of the grain. Pre-treatment of rice seed before sowing with mercuric compounds checks the disease of seed borne spores but it does not provide protection against secondary infection in the fields by spores in the air, irrigation water or soil.

Jowar :

Year	Area under cultivation
1929-30 (Pre Barrage 5 years' average)	5,92,000 acres
1934-35	4,41,084 ,,
1939-40	4,17,424 ,,

Jowar is a subtropical crop and requires a warm and dry climate. It is, therefore, uniformly distributed in all parts of Sind. Nawabshah, Sukkur and USF Districts have the largest acreage whereas Hyderabad and Karachi have the lowest. The area under this staple cereal has decreased after the Sukkur Barrage. The average yield of *Jowar* per acre according to 1934-37 years figures works out to be about 700 lbs. Besides grain, *Jowar* furnishes valuable '*Karbi*' or straw and succulent green fodder for cattle.

Improved strains of indigenous varieities of *Jowar* have been evolved by selection. Red Janapur has been tested and found to be a hardier variety, suitable for non-Barrage conditions in Upper Sind. *Acho Kodri* is suited to Dadu district and *Acho Bazigar* is suitable for inundation conditions of late and short irrigation of Upper and Lower Sind on account of its early maturity.

Jowar cultivation suffers, and sometimes seriously, from smut disease, stem borer pest and periodic locusts ravages.

Bajri

Year	Area under cultivation

1929-30 (Pre-Barrage 5 years' average)	10,77,000 acres
1934-35	2,93,278 ,,
1939-40	2,25,513 ,,

Like *Jowar*, *Bajri* is a sub-tropical crop and requires a dry and warm climate. When compared to *Jowar* however it grows on poorer soil and requires much less water. *Bajri* crop is inferior to *Jowar* as regards quality of fodder and grain.

The area under *Bajri* has considerably decreased since the construction of the Lloyd Barrage. Hyderabad and Nawabshah districts grow the highest acreage of the crop, whereas Larkana District grows least *bajri*. *Bajri* yields about 400 to 600 lbs per acre according to the average figures for the year 1934-37.

There is need of drought resistant, early maturing and high yielding variety of *Bajri* for the Barrage and the non-Barrage areas. Several types have been imported from Africa, the Punjab and Jamnagar. Of all the exotic varieties, Jamnagar Giant has been found to give the highest yield of 2½ maunds of grain per acre.

Crop Diseases and Pests:

A. The following is a list of common crop diseases in Sind :

Name of Disease	Crops affected
1. Root Pot	Cotton, Castor, *Guar*, *Till*, *Mung*, *Mauh*, *Saun*, hemp, groundnut and *bhang*.
2. *Rati* (Rust) (Black and Nairge)	Wheat, Rice.
3. Malformation	*Til*
4. Red Lead *(Mehto)*	Cotton, Mango
5. Loose Smut	Wheat
6. Green Smut	*Jowar* and *Bajri*

B. The following is a list of common crop pests in Sind:

Name of Pest	Crops attacked.
1. Pink and spotted Boll worm	Cotton
2. Jassids	Cotton
3. Black headed Cricket	Cotton
4. Mango hopper	Mango tree
5. *Jowar* Stemborer	*Jowar*
6. *Till* leaf roller	*Till*
7. Sugarcane borer	Sugarcane
8. Gram Pod-borer and cutworm	Gram
9. Red pumpkin beetles	Cucurbits
10. Melon fruit fly	Cucurbits
11. White ants	All crops generally
12. Locusts	"
13. Rats	"

Other Crops.

Oil seeds and pulses are alternative cash crops to cotton, (Kharif season) and *bajri*, sugar cane, potatoes, onions, tobacco as *Rabi* crops.

Soya (Manchurian) beans and Berseem, a leguminous crop from Egypt help to reclaim Kalar lands and to add to the fertility of the soil and improve its texture. These are also valuable fodder for potatoes and onions.

If the farmer takes advantage of the early irrigation supply now available in both the seasons, there would be still more improvement in the crops and in the maturing of corn.

Pre-Barrage and Post-Barrage Comparison :

Following table presents a comparative position regarding Pre-Barrage and Post-Barrage cultivation in Sind.

Table showing acres of cultivation in the whole of Sind for the years 1931-40
(Excluding Khairpur State).

Crop	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40
Wheat	36703	778550	1144837	989357	999052	903,093	1,099,146	1106311	1104574
Cotton	253266	344112	519600	619249	769414	901039	988792	856109	553044
Rice	1059487	1090684	1099447	1102110	1114861	1161350	1205693	1238849	1317686
Jowar	463548	465876	375120	352101	410773	386230	386771	419589	439904
Bajri	435314	476809	361763	290098	247137	230490	256184	207079	215236
Other crops including Pulses and Sugar cane	608165	580054	611986	546493	617010	729599	711147	714139	678592
Oil seeds	185387	187342	174474	127698	157871	174670	196412	201940	206741
Total of all crops	3081724	3935139	4318449	4040573	4316118	4486471	4849331	4692911	4823204

The slight set-back in the year 1934-35 in connection with crops other than cotton, is due to the new conditions of irrigation and cultivation, insufficient inundation in the non-Barrage areas and also to trade conditions e. g. for wheat in Europe and Egypt.

More Post-Barrage Statistics.

Two statistical tables appearing on the following pages show how crops are now gathered in the Kharif and Rabi seasons.

Statement showing Rabi crops in thousands of acres in Sind

S. No.	Name of system.	Wheat 1932-33	Wheat 1938-39	Wheat 1934-35	Barley 1932-33	Barley 1938-39	Barley 1934-35
I.	Barrage Area						
1.	Rohri Canal system	176.7	412.7	351.1	1.0	1.9	1.6
2.	Eastern Nara ,,	262.0	329.5	286.7	0.4	0.7	0.6
3.	N. Western Canal ,,	92.2	158.0	133.9	-	0.6	0.1
4.	Rice canal ,,	25.0	18.0	17.9	0.2	0.3	0.4
5.	Dadu Canal ,,	76.0	84.6	106.5	0.9	2.2	2.5
6.	Manchar Drainage ,,	12.2	11.3	8.7	0.1	0.3	0.1
II	Non-Barrage Area						
1.	North of Barrage Zone	93.4	77.5	84.1 (1 and 2 together)	0.2	0.2	4.7 (1 and 2 together)
2.	South of ,, ,,	40.9	19.0		5.8	6.6	
III	Khairpur State	64.78	101.7	85.90	0.93	-	1. 22

Statement showing Rabi crops in thousands of acres in Sind (Continued)

S. No.	Name of system	Oil seeds 1932-33	Oil seeds 1938-39	Oil seeds 1934-35	Other crops 1932-33	Other crops 1938-39	Other crops 1934-35
I.	Barrage Area						
1.	Rohri Canal system	21.7	17.3	8.5	27.0	38.9	24.3
2.	Eastern Nara ,,	7.9	6.9	4.9	8.5	18.8	12.0
3.	N. Western Canal ,,	41.0	64.1	35.1	41.5	63.8	52.2
4.	Rice canal ,,	15.9	18.5	13.8	93.9	135.3	102.7
5.	Dadu Canal ,,	4.4	9.9	8.4	27.7	30.1	29.8
6.	Manchar Drainage ,,	1.6	1.9	1.2	0.5	1.2	0.3
II	Non-Barrage Area						
1.	North of Barrage Zone	57.2	40.7	55.5	248.5	224.2	235.1
2.	South of ,, ,,	37.6	46.4		34.7	40.3	
III	Khairpur State	16.78	20.7	13.68	29.01	43.2	24.40

Statement showing Kharif crops in thousands of acres in Sind

S. No.	Name of System	Rice 1932-33	Rice 1938-39	Rice 1934-35	*Jowari & Bajri* 1932-33	*Jowari & Bajri* 1938-39	*Jowari & Bajri* 1934-35
I.	Barrage area						
1.	Rohri canal system	4.0	8.7	4.3	240.6	157.8	26.09
2.	Eastern Nara ,,	80.8	83.2	90.3	150.9	73.1	94.61
3.	North W. Canal ,,	59.2	120.0	93.5	102.4	74.2	59.4
4.	Rice Canal ,,	249.6	317.7	255.5	10.0	5.7	6.9
5.	Dadu Canal ,,	49.4	48.9	54.0	41.4	36.4	30.5
6.	Manchar Drainage ,,	0.3	0.8	1.2	0.7	1.9	0.8
II	Non-Barrage Area						
1.	North of Barrage Zone	191.0	266.2	603.0 (1 and 2 together)	248.9	203.4	242.8 (1 and 2 together)
2.	South of ,, ,,	456.1	471.9		147.7	101.5	
III	Khairpur State	7.91	4.3	5.09	81.75	125.6	80.68

Statement showing Kharif crops in thousands of acres in Sind (Continued)

S. No.	Name of System	Cotton 1932-33	Cotton 1938-39	Cotton 1934-35	Other Kharif including sugarcane. 1932-33	Other Kharif including sugarcane. 1938-39	Other Kharif including sugarcane. 1934-35
I.	Barrage area						
1.	Rohri canal system	84.4	386.1	298.6	21.2	41.7	24.9
2.	Eastern Nara ,,	233.0	411.4	310.6	17.2	31.5	18.7
3.	North W. Canal ,,	-	2.0	1.4	10.8	6.4	6.1
4.	Rice Canal ,,	-	0.1	-	2.4	1.2	3.1
5.	Dadu Canal ,,	0.2	22.5	3.0	4.1	3.9	4.2
6.	Manchar Drainage ,,	-	-	-	-	0.1	0.1
II.	Non-Barrage area						
1.	North of Barrage Zone	0.1	21.5	5.3 (1 and 2)	27.9	22.1	35.3 (1 and 2)
2.	South of ,, ,,	26.1	9.4		18.0	-	
III.	Khairpur State	13.03	46.2	31.10	14.05	-	17.44

A. Rabi cultivation in Sind - A comparative pre-Barrage and post-Barrage study : It can be seen from the above table that there is a considerable reduction in the acreage under wheat on the Dadu canal system from 106.5 thousand acres in 1934-35 to 84.6 thousand acres in 1938-39. Whereas there has been an increase in area under wheat on the remaining canal systems. Wheat cultivation has also decreased in the non-Barrage zone.

The cultivation of Barley has remained, more or less, steady. The area under oil seeds however has increased uniformly in the Barrage zone most remarkably on the N. W. Canal system, but decreased in the non-Barrage area.

Obviously, therefore, Rabi cultivation in the non-Barrage area in Upper and Lower Sind has greatly suffered after the construction of the Lloyd Barrage. It has, however, increased in Khairpur State.

B. Kharif cultivation in Sind - A comparative Pre-Barrage and post Barrage study : Rice cultivation has more or less uniformly increased in the Barrage and non-Barrage area alike, excepting on Eastern Nara and Dadu canal systems, where there is little decrease. It has remained steady in Khairpur State.

There has been a great increase in the acreage under *Jowar* and *Bajri* on the Rohri Canal system and in the non-Barrage tract. Only a small increase on the Eastern Nara and Dadu canal systems has taken place, since the construction of the Lloyd Barrage.

Jowar cultivation has increased from 80.68 thousand acres in 1934-35 in Khairpur State to 125.6 in 1938-39.

Cotton cultivation has increased both in the Barrage zone on the Rohri, Eastern Nara and Dadu canals systems as well as in the non-Barrage Zone. Cotton has also increased in Khairpur

State from 13.03 thousand acres in 1932-33 and 31.1 thousand acres in 1934-35 to 46.2 thousand acres in 1938-39.

Evidently, Kharif cultivation in the non-Barrage tracts in Sind has not suffered so much as Rabi cultivation.

Compared to the Barrage expectations these figures are amazingly satisfactory. As average of about ten years progress after the opening of the Barrage would only show whether this progress is going to be steady and whether the fertility of the land is to be maintained for all times. So far the cotton and wheat crops have increased to 400% and 200% respectively. In 1935-36 cotton has increased to 899,000 acres and there is a tendency to concentrate on this commodity even at the cost of wheat and other food crops in the whole province and on both the banks of the river Indus.

Problem of soil fertility etc. : Now that the question of perennial irrigation has been satisfactorily solved for Sind, other problems arise. Among these the problem of soil fertility is the most important. Under the old system of inundation, the fertility of the soil was regularly maintained by letting fields lie fallow for several seasons after each crop, and in this way exhausted soils used to recoup fertility. After the introduction of the perennial irrigation canals system in Sind in 1933, the land lies fallow only once in 5 years. Such an intensive system of irrigation and agriculture in the Barrage area is a subject of vital importance.

'Fertility' or the production of soil depends upon the following factors:-

(a) Chemical composition; (b) Physical constitution; (c) Manuring; (d) Field (tillage etc.) operations; (e) Cropping; (f) Climate, (g) Water supply, (h) Labour and capital.

The main lines, therefore, on which this problem has been investigated by the Sind Agricultural Department are:-

1. *Introduction of fertility Crop rotation:* The present system of land tenancy in Sind is quite unsuited to the systematic scheme of fertility crop rotations, because *haris* shift from one field to another, season in and season out, attempting to grow such exhausting crops as cotton and wheat instead of cultivating fertility crops which are not of immediate cash value. The results so far obtained at the Sakrand Agricultural Research Station conclusively prove that an expansion of such fertility rotations of crops in the Barrage area, in place of the old system of fallowing for recoupment, would definitely lead to greater profits both to the *zamindar* and the *hari*. Experiments to study how far the inclusion of a leguminous or a green manure crop in the usual Barrage Crop Rotation can help in maintaining the level of soil fertility in Sind, are still in progress.

2. *Convertion of crop residues into a useful compost to be applied to the lands as manure* : The principle behind this practice is that whatever food material is taken up by plants is returned to the soil by conserving and converting plant residues into a useful compost and applying it to the land.

Compost is made by collecting and conserving all vegetable waste in heaps (Sakrand method) or in pits (Indore method) and allow by them to decompose in the presence of slurry and water. Lime is added to quicken the rate of decomposition. A compost containing about 0.4-0.64 Nitrogen can thus be prepared in about two months.

3. *Use of green manure crops and artificial manures :* The use of green manure has definite ameliorative effects on the soil fertility, and artificial manures greatly help in supplying the plant nutrients in which the soil is deficient. To encourage this practice in the

Barrage Zone the Government has permitted the growth of green manure crops, which are free from revenue assessment.

The following system of Fertility Rotation of Crops is being investigated at Sakrand Agricultural Research Station:-

Kharif 1937	Rabi 1937-38	Kharif 1938	Rabi 1938-39	Kharif 1939
A. Fallow	Wheat	Fallow	Wheat	Cotton
B. *Gaur*	Wheat	Fallow	Wheat	Cotton
C. *Mung*	Wheat	Fallow	Wheat	Cotton
D. Fallow	Wheat	Fallow	Gram	Cotton
E. Fallow	Wheat	Fallow	Mattar	Cotton
F. *Guar*	Wheat	Fallow	Mattar	Cotton
G. *Mung*	Wheat	Fallow	Gram	Cotton

4. *Adoption of a system of 'Mixed Farming'* : A combination of crops and livestock production would no doubt overcome the danger of soil exhaustion; but this system of land and animal husbandry could not extensively be established in Sind, on account of the prevailing Land Tenure System.

Reclamation of Kalar lands: In the reclamation of *Kalar* lands, leaching has also proved successful. The lands are leached with heavy dose of irrigation water, which would carry away all the injurious salts into the deeper layers of soil. The process consists in a judicious concentration of the irrigation water for leaching or washing purposes and the subsequent cropping of the areas thus leached with a suitable system of crop rotation.

Such *Kalar* lands are also to be cropped, "Under a system of rotation, which includes a high percentage of crops known to be resistant to *Kalar* and which have a beneficial effect on the pysical texture of the soil and on the maintenance of dressings of certain chemical substances to the *Kalar* land with the

object of improving its physical texture and thus increase the rate of percolation and facilitating the washing out of injurious salts or of neutralising and offsetting the effects of such injurious salts on plant growth".

To prevent an upward movement of Salts in reclaimed area, the following system of rotation including green manuring and shorter fallow has been recommended by the Department of Agriculture Sind:-

	Kharif	Rabi	Kharif
A.	*Guar*	Wheat	Cotton
B.	Fallow	Wheat	Cotton
C.	*Guar*	Barley	Cotton
D.	Fallow	Barley	Cotton

The greatest success in this connection has attended the adoption of a combination of mechanical and agronomic methods of reclamation such as are practised on the Sakrand salt Land System.

Attempts have also been made to prevent conditions which give rise to the *Kalar* formation in fertile tracts, such as unlevelled lands, badly constructed *bunds* and water courses, excessive flooding of cultivated or waste areas, etc.

The Punjab Method of Reclaiming Kalar Lands : Research workers in the Punjab, have evolved an alternative method of reclaiming *Kalar* lands, which is good for comparison and consists in leaching in Kharif followed by cultivation of an early variety of transplanted *Suthra* rice. After the rice harvest in July, hemp or *guar* is sown which is buried in the month of September and the land is prepared for wheat. In the adjoining plot is cultivated long period *Thona* rice variety which is harvested in September

followed by *Debari* crop of gram and then by cotton. The rice crop besides depressing salts down below, helps to break the sodium soil complex by generating carbon dioxide from the roots.

It is, therefore, necessary that comparative merits of both the Punjab and the Sind methods of *Kalar* Reclamation may be tried side by side under local agronimic conditions. The most suitable methods may finally be evolved for reclaiming vast *kalar* areas of Sind economically and efficiently in the interest of the agricultural wealth and economic welfare of the Province.

Horticulture: A new line of horticulture has been inaugurated in the Government Farm at Mirpurkhas, after the Barrage, in the form of orchards and vegetable gardens. The possibilities of fruit growing on a large scale in Sind are great. The geographical situation of Sind as has been noticed in Section I, allows the cultivation of fruits such as dates, bananas, orange, pomegranates, figs, mulberry, melons, chikoo, mango, etc. not ordinarily grown in other parts of the sub-continent.

Fruit growing is most successful under perennial irrigation. Given the necessary protection from hot winds, close period and cold winds, fruits grow very well, grapes thrive especially well in Sind. They are the best in the sub-continent as the conditions are ideal: (1) deep alluvial soil for the roots to suck moisture, (2) very little rain, (3) very few pests. The following are types of fruits already grown:-

Kinds of Fruit	Localities
Apples (small)	Hyderabad, Karachi.
Grapes	Karachi, Hyderabad, Sukkur, Nawabshah.

Guava	Karachi, Sukkur, Larkana, Rohri, Kotri.
Mango	Karachi, Hyderabad, Sukkur, Larkana, Tharushah.
Date	Karachi, Sukkur, Larkana, Rohri, Kotri.
Orange, Lemons, Grape fruits, Santras.	Hyderabad, Sukkur, Nawabshah.
Pomegranate (Small, white)	Sukkur, Hyderabad, Karachi.
Plantain	Karachi, Sukkur, Hyderabad, Thar, Nawabshah.
Fig	Hyderabad, Nawab-shah.
Mulberry	Upper Sind, Nawabshah.
Papaya	Karachi, Hyderabad, Mirpurkhas.

Of these mango trees occupy the largest area of cultivation. There is great scope for fruit cultivation in Sind after the introduction of perennial Irrigation Fruit Preserving Industry.

Dry crops and Dry Farming: Dry crops are also now possible within the Barrage Zone of irrigation.

In addition there are extensive areas of land in Upper and

Lower Sind where irrigation water is either not available i. e., in Tharparkar and Karachi Districts or the supply is short and late on account of unsatisfactory working of inundation canals i. e., in North or South Sind. There are also large tracts in Tharparkar which are subject to periodic famine and scarcity on account of low and precarious rainfall. Problems of cultivation in such dry tracts should demand serious attention of the investigator and the cultivator.

There is, therefore, a general need of evolving hardy drought resistant and early maturing crop varieties for tracts in Upper and Lower Sind, where the irrigation water supply is late and short; whereas there is an urgent need of introducing dry farming in such tracts where crops are mostly rainfed and irrigation is not available, e. g., Tharparkar. As all farming methods of cultivation consist of growing drought resistant and early-maturing varieties, and aims at conservation and economical use of soil moisture by means of preparatory tillage, manuring, mulching, interculturing, rotation, following and cultivation of suitable varieties agronomic work has to be organised in the light of the physico chemical properties of soils and the water requirement of crops.

The following is a summary of Horticultural Research Work carried out at the Fruit Farm, Mirpurkhas :

Mango : Propagation of true mango type by grafting rather than through seed has proved to be the right method. Under Sind conditions, budding has also been found to be a successful means of propagation. Nowhere in the subcontinent has the budding of mango given such good results as in Sind. 'Madras', 'Alphouse', 'Swoaranica', 'Digga', 'Khasa', 'Bombay Alphouse', 'Neelum', 'Pairi', 'Collector' and 'Lalpata' are some of the imported varieties of mango, which grow quite satisfactorily in Sind.

Citrus (Santra) : Stock has great influence over the quality and fruiting of the scion. The Santra orange has been found to thrive best and attain earliest maturity on Sadaphal. The best from the point of view of yield is Punjab *Khatti.* The common *Jamburi* stock used in Sind bears fruit late.

Grape Fruit : This will soon attain the foremost place in the Fruit Industry of Sind. Its size, taste and flavour find favour with the public and it is a rewarding crop. March's seedless grape fruit and another 'Duncan' grape fruit imported from South Africa have been growing satisfactorily in difficult parts of Sind. The 'Duncan' variety has more seeds but better flavour. Of course, it requires an acquired taste to enjoy the grape-fruit.

Grapes : Many indigenous and exotic varieties have been grown successfully at Mirpurkhas. These have been classified as under :–

A. Early Season varieties	B. Midseason varieties	C. Late Season varieties
1. White No. 39.	1. 'Thomson,' Seedless (Raisin grape)	1. 'Muscat'
	2. *Kandhari*	
	3. Red Saharanpur	
	4. Black Grapes	
	5. *Bhokri* (Good Syrup Grape)	
	6. *Gulabi* (Table Grape)	

Training of Grapes : Kniffen or wire system of training is much less costly than the Bower or Chopra system. But the single stake system of training grape vines on a *pangara* is very

cheap. It costs Rs. 50/- per acre and has an additional advantage of allowing cultural operations with bullock labour, whereas in the Kniffen and Bower or Chopra systems only hand labour is possible.

Date : It has been observed that the date tree responds to manuring earthing up, irrigation and other cultivable operations. North or middle Sind on account of its high temperature and low rainfall is best suited for the indigenous and foreign varieties of dates.

Fig : It is a desert fruit and has a very large scope in Sind. 'Poona' and 'Hyderabad' varieties are thriving very well, whereas imported varieties like the white fig of the Punjab have not done well under local soil and climatic conditions.

Mulberry : Both varieties of white long and black long are doing well in different parts of Sind. Black 'English', 'Pecan', and 'Avacadoes' varieties of mulberry are under trial at Mirpurkhas.

Banana : Hazari, Elachi, Soneri, and 'Philipine' varieties of Banana grow satisfactorily in Sind. *Hazari* variety is a hardy and heavy yielder.

Miscellaneous fruits : The following are being tried for their suitability, acclimatisation, methods of cultivation and economic value of Sind :

1 *Chikoo*;
2 Custard Apple;
3 Peach: some promising varieties are
  (a) Free Stone Kind, viz.,
    (i) *Tiki*, flat;
    (ii) *Cheke Sufeda*,
    (iii) *Gola* and
    (iv) 'local', and

(b) Cling Stone kind viz.,

(i) 'Agra',

4 Pear;

5 Plum;

6 *Litchi*;

7 Guava,

8 Pomegranate viz.,

(i) Russin,

(ii) 'Saharanpur', Dholka'.

Cold Storage Experiments : Experiments with the cold storage of fruit have been conducted at Mirpurkhas and it has been observed that after 15-30 days of storage, fruits seem to develop a reddish colour and after eight weeks, slight blotches and after twelve weeks of cold storage, rotting sets in. However, grape fruits preserved in cold storage from 13th January to 7th May 1939 were found to be in good condition. There is, therefore, great need and scope of fruit preservation by cold storage, since the fruit industry must be commercialised in Sind.

Grading, Standardisation and Packing : For commercial purposes, the fruit should be plucked carefully and graded. After rejecting injured fruits, the rest should be cleaned and wrapped in tissue paper. The quality and size of the fruit should be standardised, and marked when the fruit is packed. After the introduction of perennial irrigation, there is a great need in Sind for fruit growing and the fruit industry.

Summary and Conclusion : Sind affords an excellent example of geographical control by a land of its natural vegetation and animal life. Man has played his party worthily in the region from time immemorial. Witness Mohenjo Daro, its mainstay being agriculture by means of irrigation throughout. But for the Indus waters, the land would have formed part of the Thar desert. Although dependent largely on the rich and varied

drift soil, natural vegetation in Sind has been influenced not only by its climate, which is the driest and hottest in the Sub-continent, but also by its position on the globe as the borderland of tropical and extra-tropical zones. Tropical fruits, flowers and grains grow well in summer, while extra-tropical grams and vegetables and trees thrive well in the bracing season of winter. There is a large number of species of plants not commonly met with in other parts of the sub-continent which have an affinity with those growing in Arabia, Iran, Nubia and Europe. This affinity of Sind with the other centres indicates that what grows there can easily be cultivated in Sind.

Six vegetation belts, including the riverain forests along the bank of the indus and the E. Nara, swamps in the delta, scrub-land in parts of the Desert province and steppe land in Kohistan, have been noticed and mapped by the author. Among the several varieties of plants are noted medicinal ones, used by native physicians for curing disease.

The system of irrigation in this dry region is perhaps the most ancient in the sub-continent. What the province has lost by way of rainfall it has luckily gained by the annual inundations of the Indus, which is the very life of the land. This river is well known for its vagaries and it has caused havoc as well, in many parts of Sind. Its floods are proverbial and yet Sind has become today one of the largest canalised land in the world through the Sukkur Barrage, which was opened early in 1932. Before this date, irrigation was irregular, unsteady and imperfect, there being many drawbacks and difficulties.

The British were successfull in their numerous schemes for this region. What with the many improvements, new work and projects, scientific appliances and last of all one of the most remarkable irrigation schemes in the world, the Barrage, the progress of irrigation of Sind under the British was steady from

the very beginning and in recent years very rapid. The river training works, such as the construction of *bunds*, are also introduced side by side with canal works, until by 1935, almost the whole length of the river banks on both sides was protected by *bunds* and 5,011 miles of main canal works with 706 miles of branches, costing over 25 crores of rupees, were constructed, and all this from a river that runs through only about 300 miles of Sind. The Rohri Canal alone became perennial, and especially in the Rabi season agriculture has grown rapidly. In certain directions the expectations for the 30 years' forecast have been reached within the past 4-5 years e. g., cotton and wheat crops are more than doubled as in Khairpur State, Cotton has come out to be the best in the sub-continent and is replacing other crops of less value. On the right bank alone, the cotton crops have already been increased to 16,000 acres of land under cultivation.

Precautions have been duly taken for the lands situated outside the Barrage zone. While Northern Sind has not and cannot be affected adversely by the Barrage, except for the vagaries of the river itself, Southern Sind distinctly suffered for want of enough of water in the Rabi season, and another Barrage for Lower Sind is now serving a sure solution of this problem. Communications are very defective in the whole of Sind and unless these keep pace with the growth of irrigation and cultivation, the best fruits of the Barrages will not be achieved. There are only a few trunk roads and canal paths and fewer railways, though Karachi is on the high way of Asian trade routes and air routes.

Progress at Sakrand and other research stations has been rapid in the direction of reclaiming *Kalar* lands by leaching etc., soil fertility, rotation of crops etc. Horticulture is another new line of culture in Sind and, all round, the Province has been immensely benefited by the Sukkur Barrage. It is left to the

economists and others now to find outlets for whatever is grown in excess in the Province.

Some Crops Raised Recently.

1. *Wheat:* Wheat is the most important crop of Sind, as it forms the staple food of the people. Quite a hardy plant, it needs less water than any other crop, thrives well in a heavy calcareous soil and tolerated a vigorous climate.

It is by far the most important crop, with flooding done in October and sowing in November-December. Winter rains being meagre, irrigation is the only chance for its growth. The Sukkur Barrage has, therefore, stimulated wheat crops in Sind, especially in the Larkana, Nawabshah, Upper Sind Frontier, Sukkur and Hyderabad districts. Nawabshah still produces the bulk of it.

The following varieties are grown in Sind :-

C. Ph. 47 (*Phandani*), A. T. 38 (*Thoree*), G. S. 25 (*Boorji*), *Pusa* 12, 114, and 80/5, Punjab 8 A and 11, Manitoba 1 Bina (N.W.F.)

Any surplus wheat crop becomes at once a cash crop and enriches the province greatly.

The acreage of wheat in Sind grew steadily from about 3,50,00 in 1899-1900 to 6,80,000 acres in 1929-30 and from that time onwards very rapidly to 13,70,000 in 1939-40. The average annual production of wheat for the quinquennium, 1943-44 to 47-48, was 378,000 tons.

One of the schemes for the expansion of food crops in Sind is to provide improved wheat seeds for the Zamindars and artificial manure to the growers, and subsidies for lifting water from the Indus, are to be provided for in the lower reaches.

2. *Rice :* Rice is cultivated in Sind as a luxury crop where ever the soil is sandy, especially in the deltaic parts. A special canal, called the Rice Canal, passes through the Larkana district which is also favoured with hill torrents from the west, often wetting the soil and making it suitable for growing rice. At the same time, nearly 5,00,000 acres are under rice, under the command of the Fuleli, Kohi and Pinyari canals confined to the Hyderabad and Thatta districts, towards the new delta.

As rice needs an enormous quantity of water, it is feared that if rice cultivation is unduly extended in Sind, it is likely to cause extensive water logging. Wheat, being the staple food here, Sind becomes a surplus province in rice, tempting the Zamindars to cultivate it more and more. It is suggested that in place of rice, other crops like sugarcane, groundnuts, vegetables and fodder should be cultivated. This requires water in some of the canals during the Rabi season, which is only possible, if they are made perennial.

The acreage of rice increased rapidly from 6,500,000 acres in 1889-90 to 11,00,000 acres in 1909-10 and then with a slight set back from 11,20,000 acres in 1919-20 to 13,00,000 acres in 1939-40. This area was at that time almost equal to that occupied by wheat.

The average annual production of rice for the years, 1943-44 to 1947-48 was 597,000 tons. In this respect also, Sind stands second in Pakistan.

3. *Cotton :* The hot and dry climate and sandy clay soil of Sind are suitable for the growth of cotton. Irrigation water runs off easily through the soil and the air needed for the growth of the plant, penetrates its inner layers. Sind cotton is thus among the best fibre crops in the whole sub-continent.

Cotton is generally grown during the Kharif season in the

districts of Dadu, Nawabshah, Hyderabad and Tharparkar.

The following varieties are grown in Sind :

1. Sind Desi. A rough variety with only 3/1″ staple. It also grows well in Khairpur State. It is suitable for mixing with wool and, therefore, exportable. The improved Desi variety is called 27 W. N.

2. Sind 'American', a most popular variety, with 7/8″ and 15/16″ staples and spinning 34 warps, is called F. 98 and grown in the Tharparkar, Hyderabad and Nawabshah districts. It is creamy white and soft and is grown on the Indus right bank.

3. *Sind Sudhar*, called 298 F. I. has the longest staple, namely 1-1/16″ and spin 40 warps. It has a ginning percentage of 30. It also resists the red leaf pest and is suitable for the Indus left bank.

4. Egyptian and Sea Island cottons, acclimatised in Sind, with 1-1/8″ and even 1-1/2″ staples, are good for spinning 50 to 80 warps. These grow well in the dry eastern parts and require better cultivation.

After the Sukkur Barrage, the growth of cotton has greatly increased. It was extremely rapid from 3,00,000 acres in 1929-30 to 8,40,000 acres in 1939-40, that is nearly 3 times.

Sind contributes almost 1/4 of the total yield of cotton in Pakistan and stands second in regard to both acreage and yield.

4. *Oil Seeds :* Sind's capacity for the production of oil seeds is of the order of 241,000 acres of rape and mustard, 13,000 acres of Sesamum and 4,000 acres of castor seeds. Oil production is greatly limited in the whole of Pakistan and Partition has disturbed its economy. There has been a continuous downward trend in the area and yield of oil seeds in the country ever since

1941-42, while requirements have increased by leaps and bounds, due to the growth of population. Oil seeds are required for cooking purposes, manufacture of vegetable oil, soap, paints, vasnishes, lubricants, etc. More areas in Sind under oil seeds, will be necessary and for this purpose the land classified as cultivable waste but suitable for raising oil seeds, will be the best. The productivity per acre is also low. For improving the present condition, the soil will have to be artificially fertilised and seeds with high oil-contents will have to be imported.

The district of Upper Sind Frontier has the largest area under oil seeds viz., 15,650 tons.

5. *Sugar Cane:* Sugar cane in Sind grows only in irrigated areas of almost all the districts. The highest of 1570 acres in 1945 was in the Karachi (now Thatta) district with Hyderabad having 1434 acres and Tgar Oarjar 1492 acres. Nawabshah had 530 acres, Larkana 509, Sukkur 129 acres, and Dadu the least acreage viz., 15 acres. Since then, there has been some improvement. It is mostly chewing cane, while the low lands can have cane for sugar as well.

There is, at present, no sugar factory in Sind, while Gur is manufactured in small quantities in the sugar-cane areas.

The total cultivation under sugar-cane in Sind is 19,0000 acres and the total production, 25000 tons, which are very insignificant for Pakistan. Tharparkar is the leading district in this respect.

6. *Fruits:* The geographical situation of Sind, being intermediate between the African sub-continent and south east Asia, the flora includes the African Iranian and Arabian types on the one hand and the tropical monsoon (Indian) type on the other. Tropical fruits do grow in summar, but in winter, the date tree first begins to ripen from the equator northwards, the apple tree produces an eatable fruit and the pomegranate blossoms for the first time.

The possibilities of growing fruit on a large scale are, therefore, great, e. g. dates, bananas, oranges, pomegranates, figs, mulberries, melons, Chikkoos, mangoes and grapes, not ordinarily grown in other parts of the sub-continent. Perennial irrigation, such as is obtainable in Sind, is their best support. Given proper protection from hot winds, close periods and cold winds, they will grow well.

60,000 acres of fruits trees are cultivated in Sind. Hyderabad being the leading area.

INDUSTRIES

Like other parts of Pakistan, Sind has also remained industrially backward, there being no large scale industries worth the name, except those of cement, fishery and salt. Skilled labour, motive power and capital are the chief bottlenecks; otherwise there is no dearth of raw materials-cereals, fibres of wool, cotton and grass, animal products, fish products, salts, hides and skins and some minerals such as clays, gypsum, etc.

Although Sind is not so industrialised, the Sindhis have, all throughout the centuries, been forced to be an industrious people. Some typical industries existed even in the Indus Valley Culture age. A large number of cottage industries have also persisted during the historical period e. g., *Khes* of Nasarpur, carpets of Bubak, *Loongis* of Thatta, and Lacquer ware, glazed pottery and tiles of Hala. Although there is a good scope for industrial development, old industries are slowly dying out and arts and crafts along with artists and craftsmen are gradually vanishing. Lacquer ware and glazed pottery are slowly disappearing from the markets of Sind.

The persian influence on the decorative art of Sind, as evidenced by the lacquer and glazed pottery works of Hala and

Thatta, has been great. This aesthetic sense still persists in the province and it only needs to be revived and encouraged.

A strange feature of Sind art is that the people living in the monotony of the desert parts, cry out for colours and exhibit them in the artistic designs they make. Sind is comprised essencially of villages, and cottage industries therefore must be developed on a large scale. Industries should not be centralised but distributed and developed near the places where raw materials and good water are readily available. It is strange to find that although Sindhi cows enjoy a world wide reputation as an excellent milk breed, there is no large dairy industry in the province. The finest varieties of cotton are grown in Sind but there are no big cotton mills. Tharparkar produces the best quality of hides and skins, but there is no great leather industry to utilise them. Spinning and weaving can and should be expanded. Poultry breeding and bee-keeping are other paying cottage industries. For reviving developing and such village industries, an agglomeration of villages should be caused. Again marketing facilities for transporting industrial goods and raw materials should be provided.

Motive Power Needed: Motive power is the most important factor for industrial planning. In Sind, no mineral oil has been found. The coal is inferior, being Tertiary, and restricted in some localities. Enough fuel can be had only after a scheme of afforestation and the utilisation of sea-weeds. A few hydro-electric power stations are likely to come into being from canal falls, connected with the Sind barrage. Only wind power remains to be considered. Even with a low velocity of 6 to 10 miles per hour, especially near the cost, small wind-mills can be put up in semi-urbanised areas and in localities of cottage industries.

Present Position of Sind Industries: At present there are some 127 cotton ginning presses in Hyderabad, Nawabshah, Sukkur

and Tharparkar districts; 92 rice mills scattered in Larkana, Jacobabad, Sukkur, Dadu, Hyderabad and Tharparkar districts; vegetable oil mills at Hyderabad, Tando Allahyar, Shahdadpur and Sukkur; 7 general engineering works at Sukkur, Shikarpur and Rohri; 6 biscuit and confectionery factories all at Sukkur; 2 tanning works at Hyderabad; and 1 each of footwear, glass-ware, Silk-weaving, hosiery, fire bricks and carbon dioxide factories mostly in the Hyderabad and Sukkur districts. About 17000 workers are employed. There are practically no large industrial schools.

Plans are now made for establishing the following industries in Sind: Match making, procelain ware, straw-board and card-board making, plywood, bone, button, soap, nail and socks manufacturing centres. To bring Sind into line with other advanced provinces, a more vigorous programme is needed. The location of such industries as suggested below, is a most important problem and it can be solved by referring to the history and progress of industries in the province and the nature of its environment:-

Potential Industrial Centres in Sind.

No.	Place	Industry	Raw Materials Used
1.	Abdu	Fans, Baskets, molasses	Grass
2.	Arazi	Painting on cloth	Paints
3.	Badin	Ghee	Milk
4.	Bubak	Carpets and mats	Wool and grass
5.	Bolahri	Quick lime Manufacture	Limestone

6.	Chachhro	*Pakhras*, *Loees*, *Khatha* (Warm rugs)	Hides and hairs of animals
7.	Dabeji	Bone ash	Bones
8.	Dahiriki	*Khes*, *Jori*, *Angochas*, and other kinds of cloth, water-sprinkler, steel-stand, boxes, axes, trunks, water jars, musical-instruments (Chang) locks, knives, scissors, painting and lacquer ware.	Yarn, wood.
9.	Digri	Woolen and leather-goods	
10.	Gadro	*Khatho*, *Doro* cloth	Wool
11.	Gambat	*Chanduis*, *Khes*	Yarn
12.	Ghotki	Snuff boxes and water sprinklers, ropes.	Grass, brass and yarn
13.	Guni	Carpets, rugs blankets, sacks, *farasis*, *Kambals*, glazed pottery, tiles, *Chiroli* and lacquer ware.	Yarn, clay

14.	Halani	*Chandnis*, *Angochas*, napkins, towels.	Yarn
15.	Halla	Tape, *Loongi*, *Jori*, glazed pottery, tiles.	River-clay.
16.	Hyderabad	Gaiters, scabbard, sword belts, jauntlets, calico printing, embroidery, bracelets, dice, spoons, knives, tiles.	Cotton, grass, hog-leather, dyes, silver, gold thread and ivory.
17.	Jacobabad	spinning, dyeing, silk-weaving, *Garbi*, *Tasar*, and embroidery.	Silk, gold and silver thread.
18.	Jhudo	*Khatha* and leather goods.	Wool and leather.
19.	Johi	*Farasis*, water jars, mats.	Cement, sand, bones.
20.	Kandiaro	Lacquer ware.	*Bahan* and *Lai* wood.
21.	Kashmore	-do-	-do-
22.	Khairpur Mirs	Spinning, Dyeing, and weaving of silk, *Garbi*, *Tasar* and emboridery, lacquer ware, carpets, tiles, pottery, Fuller's earth, soda.	Silk, gold and silver thread, *Bahan* wood, Babul bark, Fuller's earth and soda bicarbonate, salt deposit.

23.	Khanot	Lacquer ware.	*Bahan* and *Lai* wood.
24.	Kohistan	Carpets, rugs, blankets, *Farasis*, Sacks and *Khorzin*, coloured tiles.	Wool and hair.
25.	Kotri	Boat-Building, lacquer, fishery.	Deal and teak wood, Fish.
26.	Lukman	Lacquer ware.	Wood.
27.	Lundo	Lacquer ware.	Wood.
28.	Matiari	*Ajrak* Printing.	Paints.
29.	Matli	Ghee.	Cow Milk.
30.	Mehrabpur	Cotton ginning and pressing.	Cotton.
31.	Nasarpur	*Soosi*, *Khes*, tape, towel, *Angochas*, glazed pottery, tiles.	Cotton yarn and river silt.
32.	Naushahro	*Farasis*, lacquer ware.	Yarn and wood.
33.	Nawabshah	Boats (country), cotton ginning and pressing	Cotton and leather.
34.	Phulji	Leather materials.	Hides and skins.
35.	Rohri	Spinning, dyeing and weaving of Silk, *Garbi*, and *tasar*, and cement.	Silk thread, lime-stone, clay gypsum.
36.	Sann	Mats, Baskets,	Grass.

		brooms and fans.	
37.	Sehwan	Same as Rohri.	
38.	Shahdadpur	Boats and cotton ginning and pressing.	Cotton and leather.
39.	Shikarpur	Embroidery.	
40.	Sukkur	Same as in Rohri, boat building, confectionery, cigarettes, oils and scents, drugs and chemicals, fishing, oil extraction, lime and cement.	wood, tobacco, oil, limestone and clay.
41.	Tando Adam	Boats and cotton ginning and pressing.	Cotton and leather.
42.	Tando Mohd Khan	Cheese, Jams, Pickles.	Mango and milk.
43.	Talti	*Ajrak* Printing and cloth Painting.	Paints.
44.	Thatta	*Loongis*, Nets, Mats, *Soosi*, Tape, *Khes*, *Āngochas*, *Jori*, Spinning dyeing and weaving of silk, *garbi* and *Tasar*, glazed pottery, tiles, and chiroli.	Cotton yarn, grass hog leather, silk and river silt.

45.	Tharparkar Distt:	*Tobro*, *Khurzin*, *Khatho*, *Kambal*, embroidery, calico printing, ropes.	Animal hair, hides, skins, wool, dyes.
46.	Umarkot	Lacquer works.	Wood.
47.	U.S. Frontier District	Carpets.	Wool.

Average Acreage of Crops in Sind. 1949-50 (by Districts)

District	Rice	Wheat	Oilseeds	Sugarcane	Cotton	Fruits.
Thatta	2,15,982	3,288	16,511	1,366	84	11,494
Dadu	1,48,131	92,839	22,750	47	23,843	1,305
Larkana	3,40,337	1,04,676	65,115	172	1,849	8,884
U.S. Frontier	1,77,480	53,840	45,650	28	55,933	2,479
Hyderabad	2,73,559	2,40,811	38,956	1,908	2,53,842	11,991
Tharparkar	75,536	2,27,712	8,208	2,693	5,80,426	5,041
Nawabshah	736	3,22,514	15,286	2,321	22,994	6,189
Sukkur	1,44,062	85,183	16,894	243	1,99,804	11,439
Total	13,77,872	11,31,863	2,29,370	8,778	9,38,365	58,822

Areas and Yield of Princlpal Food and Cash Crops in Sind

Crops	1948-49		1949-50		1950-51	
	Areas in Acres	Yield in Tons	Areas in Acres	Yield in Tons	Areas in Acres	Yield in Tons
Rice	12,20,616	5,48,870	12,80,591	5,56,371	13,76,440	7,13,734
Wheat	13,74,301	3,74,430	12,73,929	3,25,701	12,64,673	2,71,001
Bajri	6,71,141	51,739	7,45,102	72,840	7,95,550	82,834
Jowar	3,60,233	73,102	3,75,214	73,581	3,83,174	82,478
Barley	26,910	7,688	27,145	4,674	25,221	4,505
Gram	4,18,066	87,727	3,36,271	68,182	3,63,337	64,881
Sugarcane	12,722	18,336	16,698	21,695	16,937	64,881
Rape & Mustard	3,35,862	52,062	2,27,658	34,172	2,68,699	38,385

Sesamum	12,210	1,348	10,718	1,097	13,317	1,902
Castor seed	3,440	Crop failed due to scarcity of rain.	335	71	450	16
Cotton	A. 6,43,607 D. 74,979	A. 2,59,154 D. 35,912	A. 6,98,456 D. 84,095	A. 2,80,326 D. 33,638	A. 36,157 D.75,753	A. 2,97,146 D. 41,099
Total A. and D.	7,18,586	2,95,066 (Bales of 400 lbs. each)	7,82,551	3,13,964 (Bales of 400 lbs. each)	8,11,910	3,32,245 (Bales of 392 lbs. each).

Note. A. American Cotton
D. Desi Cotton

Economic Potentialities of the Districts: Sind has a wonderful array of political divisions, called districts, which vie with one another in enriching socially, culturally and economically the whole province and thereby the whole of Pakistan.

1. Sukkur, which has also given its name to that stupendous irrigation system, the Sukkur Barrage, the largest in the world, has been the greatest force in recent years. Bukhur Island, known even to the Greek explorers, and Aror, the ancient Hindu Capital, are still good old relics, worth visiting every time. The Barrage situated within it and, commanding 7-1/2 million acres of land and more, is actually the El Dorado of Sind. It has revolutionised Sind's economy completely, as the crops have increased more than 100-200% within a short time. That it is a rare boon to the people can be proved by a single example. Usually a moderately deep well, for irrigating a field of one acre of land in Sind, costs Rs. 120, over and above the lifting charges; but the water supplied perennially, for both the Khariff and Rabi seasons, under the Barrage System, costs Rs. 33 only per acre of holding. All the Sindhi *Khatedars*, small or big and even the Sindhi *Haris* are bound to make good profits by agriculture and to raise the standard of living thereby. No wonder that the entire barrage debt of Rs. 22.5 crores, which Sind owed to the centre, could be liquidated within a decade and a half due to the impetus of war-time productions, and Sind at once became a surplus province. With the production of hydro-electricity from a fall in the Rohri canals, Sukkur promises to be a flourishing industrialised city.

2. The district of Nawabshah is perhaps the most fertile land prosperous of all, the 'bread basket of Sind'. It is really a miniature Sind in itself. It is the greatest producer of wheat, Desi cotton, *Jowar*, oil seeds, vegetables and even fruits in the province. This fertility the district owes to its irrigation system, particularly the power of the Rohri canal. Settlement is the key to

civilization and here for many centuries the peoples, including those of the Indus Valley Culture, of Chanhu Daro and Narujo Daro came and lived. By means of proper water conservation and systematic land use, it has prospered. Even the virulent *Hurs* can be re-settled, side by side with the immigrants in peace and prosperity on its soil.

3. Larkana. (Old Chanduka), a similarly fertile sector, much revived after the Sukkur Barrage, also has a long history of its own. Here lie the ruins of the world famous Mohenjo Daro and here a net work of canals provide water for the production of millions of tons of food grains every year. Even rice grows well, a special Rice canal having been provided to enrich the land. Up to the time of partition due to its fertile soil and good water supply it had the thickest population in the Province and has now a density of 179.

4. The resources of the Manchar lake, the only one of its kind in Sind and the remarkable inward and outward flow of the Aral stream acting as a safety valve for the Indus flow belong to the Dadu district. It possesses one of the oldest human settlements in the Indo-Pakistan sub-continent, namely Sindomana or Sehwan, which saw many heroic scenes in the history of Sind. The varied fishery of the lake also await its exploration.

5. Hyderabad, formerly considerably Hinduised by the *Amils* but now harbouring an extraordinarily large Muslim population of "New Sindhis" also has a great future, owing to the inception of the Lower Sind (Kotri) Barrage, which will bring over 3,000,0000 acres of New land under cultivation, with 75,000 acres also of new forests, at a cost of some 24 crores of rupees. The density of population is now the highest in the Hyderabad district including the city viz., 198 owing to its nearness to the river, its central position and railway junction. Surely it will help to turn Sind from a deficit province into a self-sufficient and even a surplus one, as was previously done by

the Lloyd Barrage. Crop yields may reach four times the present level and if Hyderabad is again declared the capital of Sind after a lapse of a little more than a century, there are chances of its being rapidly industrialised in many ways. As a great centre of learning it augurs well, the University of Sind having been already moved there.

6. And what shall be seen of the district of Tharparkar, a large part of which has been already revived by the Eastern Nara after the Sukkur Barrage ? A desert is now blooming into a rose which can be best exemplified by the Sind American cotton; it is most benefited here because of the dry climate and suitable soil. A desert only in name, it can be more revived by tapping the hanging water-tables which are now known to exist.

7. A similar fortune awaits the district of Upper Sind Frontier a contrasting region belonging to the Kachhi desert in the reentralnt angle, parts of which also fall into the Sibi district (Baluchistan). Much irrigation and engineering skill will be required to revive this neglected corner of Sind. A third Barrage already conceived as the Upper Sind Barrage, if constructed at Gudu or any other suitable point on the Indus, is sure to be a boon to this district.

8. Lastly, the new district of Thatta (old Karachi district-a misnomer after Sind has been shorne of its rich capital in 1947), is on the eve of resuscitation. By the creation of the new district of Greater Karachi, this political division has lost some 560 square miles of land. Parts of it fall into the barren and rocky Kohistan area in the north and the swampy deltaic land in the south. The development of fishery, a new river port and a bright navigation and industrialisation programme, however, will save this district from catastrophe. Thatta, the old capital of Sind province, is rising in importance and is likely to be more pros-

perous after the Kalri canal becomes perennial, when the Lower Sind Barrage is in action. Thano Bula Khan promises to be a good semi-hill station here.

CHAPTER IX

NATURE OF HUMAN SETTLEMENT - OLD AND NEW

Instability has been the fate of all human settlements in Sind. Throughout human history, nature has tried to defeat them, but at the same time Man has attempted to upset Nature's plans, by making full use of the resources and even modifying his environment if necessary. Soil and water were the first problems to be tackled by the settlers. Then, there came the need for permanent settlement in different parts of the Indus basin - hilly areas and valley lands, shores of lakes, banks of rivers and the coastal region etc. How this has been done, it is the purpose of the present chapter to show.

Settlement, in general, bears a close relationship to geological features, topographical, climatic and other conditions and also the power of human beings to alter these factors. "Historical geography is essentially a study of environment and involves the reconstruction of landscape at various periods of human development." The story of Sind for many centuries has been told in terms of its changing streams and river beds, changing lakes and sand-hills, changing creeks and river mouths, and there is little of its surface now covered with sand and silt both in the desert and the river valley areas, that has not been cut up by old channels. Thus the basin affords an excellent example of human endeavour to make history in evolutionary geographical conditions. Thus in studying the interaction of geography and history in Sind, there are changing aspects to be considered. In fact, it is in such a geographical setting that it is easy to see how

human society has successfully functioned and evolved itself.

In this very basin of the Indus was born the earliest civilisation of the Indo-Pakistan sub-continent; indeed, one of the earliest homes of mankind was established here. Since then, countless generations of people have come in and passed through to the mainland or gone abroad, utilising Sind for some time as a halting place. There always has been the river Indus, flowing for hundreds of miles, and falling through thousands of feet, from the world's highest mountain into the depths of the Arabian Sea. The river itself has a chequered career throughout geological and historical times. Carrying all the combined waters of the Punjab it has brought to Sind rich silt, clay and sand, and where there are no rocks or other obstacles, it has preferred to wander from side to side. So, particularly in its final deltaic stage, the river, because of many changes in its branches and mouths, has afforded no permanent settlements for man.

Yet this river has given shelter and life to numerous ancient tribes and has caused various forms of government to prosper or to perish. In its waters, religious people have bathed, and merchant ships, country craft and vessels of war have sailed; the ancient Vedic Aryans, Iranians, Sumerians, Greeks, Indians-all have sung song of praise to the Deity, on the banks of this sacred river, for so they called it.

CHANGING ASPECTS OF THE COUNTRY

Frequent change has been the predominant characteristic even of the pre-historic geography of Sind. An antechamber for the whole of Hindustan, because of the uncertainties pointed out, its earliest settlements were very unsuitable. Many Sindhi towns rose and fell with the floods or other natural phenomena, new ones were established in more convenient places or the old ones rose again on higher ground, after the floods had subsided; many more came into being on other banks or streams, near

newer coastlines, at times with identical names to continue the tradition. To-day the great river has but two fixed points in its course about 500 miles throughout Sind, viz., Bukkur (ancient Behker) and Kotri, neither of which, however, even to-day boasts of a large population. Although there was room for large and agglomerated settlements, natural forces did not allow them to continue long. With time, there came into existence large and flourishing towns, sea-ports, river-ports, even manufacturing towns on newer fresh-water streams and lakes and river channels, which were converted into irrigation canals or highways. All these habitations have undergone changes of a far-reaching character with the result that Sind has a distribution of population, which shuffles and reshuffles itself and is also in some parts migratory.

The earliest penetration of human beings into the valley must have been by land through the mountain passes of the Western Highlands, in search of food, grass and water. They appear to have settled at first in the valleys of the Tertiary rocks in the Kohistan section particularly the *Baran*, the *Nain* and the *Bandhni* valleys. Due possibly to a greater rainfall and the existence of hill torrents, and to the presence in the neighbourhood of flint available in limestone outcrops, early Stone man established his first 'factories' here. Advancing further, Bronze man moved to the Manchar Lake and the Indus Valley (Western Nara). Later on, due to the menace of floods historic man tried to settle down or build temples on mounds and raised ground in the valley, on island towns and near rocky projections. Later still, sea-faring races sought the delta and the coast land for trade. Agriculture, however, being the greatest industry in a region like Sind, succeeding generations of men chose the whole river valley, flood plains, canalised parts of the desert, and so on.

The densest population in past ages was more on Old

Alluvium, covering Chanduka and Larkana districts, where the soil was essentially loamy and rich, and the land, like a *Doab* was drained by hill-torrents on one side and the Indus on the other. Along the banks of the Hakra, too, there were settlements but these are now covered over with sand.

The result of our enquiry into the historical correlation of Sind has also shown that there have been great fluctuations in the centres of Government and military power in the land. Sind's centre of political activity has shifted from the Western Valley Section to the Eastern Valley Section, then from the Northern areas to the deltaic land, then again to the midlands and the Indus valley proper. Attacks from outside and ingresses into the province, through the convenient mountain passes and some of the mouths of the river have been frequent and periodical. At the same time the physical nature of the region and its divisions made it difficult for any central government to exist for a long time even over a portion of the land. One race after another came, settled at suitable places for the time being and then passed on, leaving its influence behind.

The nature of the coast being uninviting, there was partically no coastal population. If there were any important settlements in Sind, they were inland, in the then well-watered Kohistan valleys, along the banks of rivers, their branches and canals, on the trade routes, even where they passed through the desert belt. A few towns were also established as out-posts of larger settlements, which commanded the cultivated fields on the frontier, in spite of the severity of the climate in Upper Sind. Most of these settlements, however, were transitory.

Parts of present day desert land appear to have been so populated, although archaeological data in Sind is very scanty. There was a possibility in the past of an extensive population in this desert part of Sind as well as in the neighbouring tracts of Cutch. No doubt the sea also flowed where there are now

sand-hills and silt deposits.

On this subject of great changes in the land, historians have said enough.

"This saline plain (*Rann* of Cutch) was certainly at one time flooded by the seas, as shown by the abundance of salt and by the remains of shells dug up near the neighbouring villages. Old harbour works are observed near Nagar Parkar. On the Eastern side of the *Rann* within historical times, it was probably the scene of an active sea-trade; even in modern times the port of Mandavi on the southern coast of the Cutch, carries a direct trade with Zanzibar, in small vessels averaging 50 tons of less than 10 feet draught.

"The whole area was probably raised by some great earth-quake. The upheaval is too regular to have occurred through ordinary causes. At the time of the Peripuls, it seems to have been open water, although shoal, with a clear opening into the ocean below the Indus delta, and with a branch of the Indus running into it. Now the Indus delta is pushed very much further south and the scour of the tides have carried its alluvium along the coast, almost locking up the *Rann*; while the branch that watered it no longer flows in that direction.

"One is led to surmise that the great migration from Cutch and Gujrat to Java which occurred in the sixth and seventh centuries and which led to the establishment of Buddhist kingdoms there (surviving in the tremendous temples of Boroboedor and Baramanan), may have been due even more to this cause than to the invasion of hostile Aryan tribes from the upper Indus. The conversion of a navigable bay into a salt desert and the diversion of the rivers that watered it, must have spelled ruin and starvation to multitudes of its agricultural and sea-faring inhabitants, who would have been forced to migrate on a scale unusual in history.

"Geological considerations tend to confirm the tradition, otherwise unsupported by historical evidence, that the Indus was formerly deflected by the Rohri Hills directly into the *Rann* of Cutch, where it was joined by the river, which was supposed to have formed a continuation of the Sutlej and Sarasvati through the now dried up Hakra (Wahind) canal. During exceptional floods the waters of the Indus still overflow into the eastern desert and even into the *Rann*. Other channels, traversing the desert further south, still attest the incessant shifting of the main stream in its search for the most favourable sea-ward outlet. According to Burnes, a branch of the Indus known as the *Purana* or Ancient, still flowed in 1672 about 120 miles east of the present mouth. The constant shiftings of the river bed towards the east have rendered the western regions continually more arid and have changed many river channels into salt pits."

It is to be noted that the Indus basin (Sind-Punjab) with its drainage is not the only part of the sub-continent. "Changes in the course of rivers, coastline altered by earthquakes, mountains in process of formation - such are the characteristics of India's changing map." In fact every monsoon season means a change in the course of an alluvial river or deltaic land, every year the younger mountains of extra-peninsular India are in the slow process of settling, upheaval or drift, with earthquake shocks felt now and then, or the older rocks of Peninsular India are denuded away by the subaerial agencies and the river deltas undergo changes. Whether in the valleys of the Brahmaputra, the Jamna or the Ganges, or in the valleys of the Punjab rivers, or even in the case of some of the rivers of the South, there are records of ruins of old settlements, which came into being and vanished.

The ports of Korkai and Kayal on the Tinnevelly coast, Puhar at the mouth of the Cauvery River, Tanda on the Pagla river in the Ganges Valley, the river port of Hijli on the Hughli, Patliputra at the junction of the Sone and the Ganges, Jamalpur

on the Barahmaputra-all these are examples of hydrographical changes in India. Elaborate river-training works made by man, have now fortunately averted disasters in many parts of the sub-continent, e. g., those in connection with the Hardinge Bridge, the Sutlej railway bridges, etc. *Bunds* and other protective works are constructed on the up-stream side and on both the banks for several miles to ensure safety of bridges, culverts, fields and farms during the monsoon or flood season. Otherwise old history would repeat itself especially in modern Punjab, Sind, Bengal and Bihar.

Thus the problem of the location and identification of old sites in India is very difficult. The most significant is the example of the Indus and the Hakra-Wahinda river systems within the region of our study. Students of Indian history are familiar with the many attempts which have been made to trace India in the fourth Century B. C., but so great have been the changes in the river courses that most of these attempts are certainly wide of the mark and, at best, only a broad approximation is possible.

"Alexander's long river voyage to the sea, on leaving India, is assumed by most historians to have been made on the Indus, but the map has altered enormously since those days and it is far more probable that he sailed down the famous lost river, the Hakra.

Besides hydrographical changes, there are evidences of other changes worth considering, e. g., climatic, tectonic, political, etc. Not only in the field of irrigation and agriculture but also in trade and commerce and even lines of pilgrimage, man has made his mark and left vestiges of his habitations and activities throughout the historic periods.

CHANGING ASPECTS OF SIND.

Thus by combining the factors of 1) Relief and drainage,

2) Climate, natural vegetation and animal life, 3) Irrigation and agriculture, 4) Geomorphology, and 5) Hydrography, it is possible to prepare a map of Sind settlements for all times. The task of identifying several old towns in Sind is particularly difficult, as few historians or geographers agree on any principle of identification and their opinions are conjectural, confusing or contradictory, e. g., Raverty and Elliot. Unfortunately, the best aid of archaeology in the identification of old sites is greatly lacking, the discovery of Mohanjo Daro itself being accidental; full advantage has not yet been taken of Majumdar's excellent Sind survey in further systematic excavations. Cunningham and Cousens did their best in their time, and recently Dr. Mackay's excavations in the Nawabshah district have been greatly valued. However, we hope to arrive at some definite conclusions as regards the physical changes and the location of prehistoric and historic sites, by producing both the physiographical and historical evidence side by side.

A comparison of old maps of Sind with a modern survey map showing the density of population by towns and villages according to the Census Reports, will also enable us to prove the thesis of Sind's changing aspects and the possibility of a more or less settled population after the construction of the great barrage project within the Indus valley.

Reading and Comparison of Old Maps of Sind :

1. It was a river-valley civilisation and its prosperity was entirely due to its fertile soil and plentiful supply of irrigation waters.

2. Both the distributaries and the mouths of the Indus river have all changed through out the centuries.

3. Some settlements were also established within the loops or meanders of the river e. g. Al Mansura.

4. Settlements were destroyed by the very river, which gave them birth and shelter, by means of floods, out-offs or avulsions etc.

5. Many of the river ports also came into being and disappeared because of excessive silting of the mouths. Debal (?) alone persisted because of its favourable location and its safety from floods and tidal waves, during the Arab occupation of Sind.

6. Even Patala, established by the Greek invaders, at the head of the Delta has disappeared from the map.

7. Several other places were noted during later periods until Thatta at the head of the fresh deltaic formation, became the capital of Sind in the 19th century. This town, although it is still in existence, has lost its importance; NirunKot (Hyderabad) has followed suit, and new Karachi, having an excellent sea port and safe harbour has for the past century come into the lime-light.

8. Other maps drawn during the British period, show the use of several small river channals, e. g., Eastern Nara, Western Nara, the Dhoro Puran, the Hakra-Wahinda, etc., the Aral-Manchar lake system, and some of the old and abandoned channels, like the Kalri, the Gharo, the Baghar, etc., all flowing at some times but drying up at others.

9. The present river mouths are 11 in number, but as many as 23 mouths have been pointed out on the map.

10. Lastly, the floods of the river Indus, called Mehran by the Arab setlers, have still been persistent and violent. Thus, inspite of the *Bunds* or embankments, they are destructive on the one hand and productive on the other because of the rich silt deposited every time in the valley.

Attractions for immigration into Sind: A large proportion of the population in the past must have been attracted to the Indus Valley for the following reasons:-

1. *Evolution of Steppe-nomadic life on the dry Iran plateau:* So much and so varied were the onslaughts on the valley from tribal chiefs and aspiring conquerors, and from dry plateau lands that it is not difficult to say that among the earliest immigrants into Sind were the Iranians and those nurtured in Iranian culture, on the Central Asiatic plateau, which is supposed to be the house of the Aryans. In the growth and evolution of steppe nomadic life there was a thirst for the conquest of settled countries like the Indus basin.

2. *Fertility of the Soil:* The soil being extraordinarily rich, people sought the best parts of Sind for settlement within the valley, inspite of the dangers of floods etc. etc. It was drift soil from the mountains of the extra-peninsular area, and therefore was productive in the extreme.

3. *The Indus*: The river was another great attraction for people not only for a plentiful water supply in the otherwise dry basin but also as a water-way, a fishery depot and as a unique fertiliser of soil with silt, brought down with the floods. The earliest canals were inundation canals of the Indus.

4. The crops were double, *Kharif* (Summer) and *Rabi* (winter) a regular alternation of harvest throughout the year.

5. *Passion for conquest :* Every conquering tribe or race brought in a number of immigrants to settle down, though after a time they moved on to the upper Indus basin or to the Ganges basin and beyond. To some, Sind was a geographical necessity for further conquests, e. g., the Arabs and the British.

6. *The deltaic Ports :* Although the Indus delta was not very

attractive and there were no great and permanent harbours in it, because of a very prosperous hinterland, there were ports like Patala, Debal, Lahri, Shah Bunder, Ghora bari and others, which carried on trade with fertile and prosperous valley like Mesopotamia.

7. *Ultimate exodus into the neighbouring provinces* : Finally Sind was distincly a stepping stone to the rest of the sub-continent for natives as well as foreigners. An exit was not only possible but also inevitable.

The political factor has to some extent contributed to changes in human settlements in the region, although at the same time, political onslaughts, invasions and raids on Sind were themselves due not only to the growing struggle for food and water in the neighbouring highlands and table-lands, but also to religious differences, and the lust for conquest and trade. Among the earliest historical establishments of military posts were Patala at the head of the then delta, and the two ports on the eastern and western mouths of the river, established by the Greek conqueror. In the days of the Hindu Kings of Sind like Chach, Alor formed the proper centre of government for "Greater" Sind, over which they extended their power even as far as Kashmir in the north, before the Arabs took over from them. Because of their inaccessibility the Sumras still inhabited parts of the eastern desert land and the Hakra valley at the same time as the main Indus valley was occupied by the Arab conquerors. When the enemy forces were withdrawn, they tried to re-occupy the delta country lower down e. g. Samui (Tatta).

While the Arabs themselves were in power, they established Mansura near the ruins of old Bahamnabad, as their capital; the Rajput rulers who were driven out into the desert in the east had to choose Mahmmed Tur as their outpost; the Daudpotas fixed Shikarpur on the highway to Iran as their centre of

government in preference to the earlier choices of Bakkar or Nasarpur, and when Sind fell into the hands of the Delhi emperors, they made Bakkar Island, again, their governor's residence in preference to Thatta in lower Sind. When Nadirshah invaded Sind, Shikarpur on the highway fell naturally into his hands and, it became a great trading centre between Afghanistan and Sind. The Kalhoras, who claimed affinity to a race of medicants in the Chandukah district and who were builders of such big canal systems as the Ghar, concentrated their forces on the right bank of the Indus and even fixed Khudabad as their principal town. The damming of the Puran river by Mian Ghulam Shah with the purpose of turning a portion of Kutch into a desert is another instance of political forces working in the land. The Talpurs, before they succeeded the Kalhoras, were also forced to establish a few outposts in the *Pat* Section e. g. Islamgarh. it was a political necessity for the British to occupy the channel of the river Indus and to exchange the fertile parts of Northern Sind for portions of the sandy desert with the Mirs of Khairpur State. The British themselves, with their maritime power chose the port of Karachi for their headquarters in preference to Hyderabad, after the whole of Sind had been conquered by them.

THE PHYSICAL FACTOR

The physical factor however is more powerful than the political, and it is necessary to consider this in all its bearings on Sind settlements.

1. *Climatic Variation:* Let us first of all consider the question of climatic change in this region. The greatest exponent of this is Ellsworth Huntington, whose theory of pulsatory climatic changes for many thousands of years, has been criticised, e. g., the period of 3,000 B. C. to 1,400 A. D., as the curve drawn by him shows, is indicative of numerous pulses. He tries to find everywhere 'abundant indications of a change

in climate', and 'densely populated, higher civilisation' in the ruins now buried under sand or lying barren on the dried up shores of lakes or river banks.

He regards climate as closely connected with civilization and asserts that "a favourable climate is an essential condition of high civilisation."

A study of central Asia, Turkestan, Palestine and Ladakh shows that there were fluctuations in the humidity and dryness of these areas at various times, with the result that from time to time, hordes of nomads left their barren homes for better and more congenial ones, both in the east and in the west. British geographers are loath to accept the theory of climatic change and give other causes for the destruction of grasslands, agriculture and settlement, in steppe-nomadic life, such as the practice of agriculture on too thin a soil, too much rain washing away the soil, exposed by ploughing or too little rain causing windswept dry soil. Over-grazing and prolonged war would also destroy good cultivated lands. At the same time they are ready to acknowledge that 'Climatic variation might add impetus and emphasis to either dispersal or concentration ! So far as Sind is concerned, it is not possible to obtain any clear evidence to prove such great fluctuations in climate. On the contrary, from the few archaeological remains which have already been dug up, we can surmise that the high summer heat for which Sind is known, has not appreciably diminished, since the days of Mohenjo Daro. The best example is that of the baths, especially the central public bath which must have been utilised by common people more than by the well-to-do. The sculptures of Indians made by Darius at Hamadan show them naked or with the very scanty garments typical of a hot and arid climate.

Alongside this can be placed the argument advanced by G. F. Oldham and others that, had the rainfall of the Punjab and Sind been greater at the time of the settlement of the Vedic

Aryans on the Sarasvati, in Aryavarta about 1500 B. C. the land would have become marshy and uninhabitable. Sanskrit hymns were even composed by them in connection with rainless days and droughts. More rain on the Siwaliks (Lower Himalayas) would have meant more waters in the Ambala stream and greater and more disastrous floods in Sind. At the same time, archeological evidence is in favour of ascribing a climate with a somewhat greater rainfall to this prehistoric period in Sind. It is possible that Sind experienced a better climate in the days of Mohenjo Daro and Chanhu Daro, the best proof being the chain of prehistoric sites, discovered by Majumdar within a definite zone, parallel to the Khirthar mountains in the Kohistan region, e. g., Wahi, Ali Morad, Shah Hasan, Pokhran, Karchat, Khojur, Shahjo, etc. There must have been more powerful hill torents and sufficient water supply to enable such a large number of settlements to flourish in this dry part of Sind, before people moved on to lower levels in the valley. "The stations of prehistoric culture, discovered in this region were very closely situated to one another, forming a chain, as it were, running parallel to the Khirthar Range. At none of the sites again has been traced any sign of re-occupation after the Chalcolithic times, and at present no permanent human settlement exists in the neighbourhood of many. Judging from the large number of stations existing in such a narrow compass, this part of the country must have been much more densely populated than it is now. To the west of the Khirthar and the River Hab, in the Jhalawan and Makran Districts of Baluchistan, Sir Aurel Stein has discovered a similar chain of prehistoric sites, and at some of these he has been able to detect clear evidence of dessication".

Putting these facts together, it seems plausible that one of the reasons for the abandonment of sites in Western Sind was the appearance of a drier climate. And for this reason or another, "the people gradually moved towards the rich food-producing

lands of the alluvial Indus Country. The Manchar Lake itself on this very account must have been broader and vaster. One piece of evidence given by Majumdar is the number and type of pile dwellings along its shore, showing that it harboured a fishing race.

In prehistoric times, the people were particularly afraid of settling on the banks of the Indus, it being more violent in its floods than other rivers, and so they must have selected these sites of the Manchar Lake and the higher levels of Kohistan, which are now so dry and covered with sand that there is very little greenery or other attraction for settlement. Thus at least different climate was possible in the region, some 5,000 years ago. In more recent years, the climate may have become a high-pressure (monsoon) belt.

With the growing mass of sand hills in parts of the valley, there is a gradual rise in the ground level and hence a drop in the water table, which within the Thar desert is considerable, viz., 500 ft. below the surface. Not only sand but also salt in laıge quantitıes is blown in from the Rann of Cutch and desiccation is thereby accentuated. There is no surface or subsoil evaporation at all here. The high range of temperature in summer, the action of wind currents and rain water in flood times on soft Tertiary formations cause a considerable disintegration of rocks and accumulatıon of sand, thus, helping the process of desiccation.

With this, there is evidence of receding glaciers in the Hımalayan region. At least two of the rivers in the Indus system, the chief sources of water in the valley, are snow fed. Much depends, therefore, on the periodic dıminution or augmentation of glaciers in the mountains. At present, a shrinkage of Himalayan snow-fields is noticeable. There thus appears to be a distinct variation, if not a change, in the climatic conditions of

the Indus Valley.

2. *Geomorphology:* The changes made in the human geography of Sind by other natural changes are more important.

(i) *Valley Form:* That the Indus in its lower reaches is an aggrading river has been already shown. The form of the valley, therefore, in the lower basin is unique. The river bed is now on a ridge higher than the surrounding country, aggradation being heavy and the process of silting continuous; old alluvium (*Bhangar*) is found on the right bank largely covering the Larkana and Upper Sind Frontier districts. The rest of the province is covered with new alluvium (*Khadar)* after periodical and heavy floods.

An examination of the deposits in the Khadeji river valleys shows that there must have been Pleistocene river deposits in Sind. Fresh-water shells are found in them covering the valley, and the present bed of this river is narrow and cut within these fluviatile deposits, showing thereby that the past physical conditions differed from present ones. Many features of Sind's prehistoric geography are exposed in such dry river valleys.

In many parts of Kohistan, subaerial agencies have reduced valleys in fractured anticlinal folds. This process is still continuous and the work of denudation and transportation of material is completed by winds blowing from opposite directions in the hot and cold seasons. These low flat-topped hills and broad elongated valleys are characteristic features of the Sindhi landscape. Where there are surface springs, hot or cold, in such a region there are changes of settlement, however, transitory.

(ii) *Subsidence and Upheaval:* There are no signs in recent times of submergence in Sind. The submergence of the Indus gorges off the present coastlines has been noted. It was indeed a unique subsidence: "On the west side, opposite the present mouths of the Indus River, lies the Indus 'Swatch' that cuts through the

edge of Continental Shelf, commencing at a depth of about 30 metres and at its mouth reaching a depth of about 1,134 meters on each side of which the walls of the gully rise up to a depth of only 200 metres." The drop in the level below *Allah Bund* after the Cutch earth-quake of 1819 was also remarkable. A very wide area was affected by it. On the other hand, there are distinct signs of a gradual upheaval of the land, e. g., the Oyster Rocks off Keamari, the coral beads at Mango Peer, and the salt lakes *(Dhandhs)* in the desert section. That the sea has gradually receded can also be easily seen on the shore at Clifton. Thus the land is generally rising, and there are more changes of the driving up of springs and the desertion of settlements thereby, than by sumbergence in such quarters.

(iii) *Aeolean Deposits:* The whole of the desert province is covered over with sand-hills, which change their direction and size in different seasons. The burial of human habitations and settlements underneath these hills is certain.

(iv) *Delta Growth:* There are clear signs of the Indus delta advancing, viz., an increasing foreshore, changes in the mouths of the river in the inlets of the sea and in the river ports, the growth of the mangrove swamps and the accumulation for many miles of sand-hills. Debal, Lari Bundar, Shah Bundar, Ghora Bari, Keti Bundar, and Sukhi Bundar, thrown inland one after another, are evidences of the delta growth of the Indus. According to Haig, the present rate of growth is on an average about 4 yards a year. The rate of growth in earlier ages must have been greater, e. g., 20 yards annually about 5,000 years ago, when Mohenjo Daro flourished.

(v) *Subaerial Disintegration and Denudation:* The subaerial agencies are constantly at work at the same time on the rocks in the hilly parts of Sind. Here soil erosion is very great and surface run-off is too rapid for any soil resistance. Long periods without rain are followed by torrential downpours. The effects of solar

heat and wind currents are greater than those of rain water. Wherever there are changes, surface springs, which are perennial, appear in rock ravines, indicating sub-artesian conditions due to accummulation of detritus at lower levels and faulting and fissuring of the numerous anticlinal folds. Nearby, there is sufficient grass on which sheep and goats can thrive for a time.

(vi) *Effects of Floods :* Since the age of Mohenjo Daro, floods have been the most dreadful menace to human habitation in Sind. They are caused by the agencies of thunder storms and the Indus inundation. They are periodic and thereby settlements are greatly disturbed. The chief cause of the frequent evacuations of Mohenjo Daro was the inundations of the Indus. The number of other *Daroes* or towns established on MOUNDS in Sind are also a direct evidence of the terrors of floods.

3. *Tectonic Changes :* Sind falls within the danger zone of North-West India, and a large part of Western Sind actually lies within the range of severe earthquakes, recorded since 1850, e. g., Quetta 1905, and 1935. The younger Tertiary rocks of the Khirthar range are still in the process of settling, and now and then a shock is felt, and an upheaval or subsidence takes place here and there in the zone. The growing Indus delta may also have something to do with the occurence of earthquakes here. It is the considered opinion of geologists like R. D. Oldham, however, that earthquakes do not cause changes of level on a wide scale. Any such change is usually very local, although the damage may be severe. "Slow changes, unnoted at the time and unaccompanied by sensible disturbances, are much more effective." Regarding the tradition of the Alor earthquake of 962 A.D., Oldham writes : "I do not recollect anything of the earthquake which you mention, but very much question its having made any great change in the main course of the Indus." In his opinion, the tradition seems to be a recollection of events, which really happened, or an offspring of some attempt at a

theoretical explanation of a striking peculiarity.

No systematic record of earthquakes before 1850 has been kept, but it is likely that the land, within the danger zone, has suffered from disturbances and tectonic changes, which though localised, have taken place in the past. Bahmanabad is known to have been destroyed by an earthquake, from the discovery of the ruins before the establishment of Mansura by the Arab conquerors in the 8th. century. Other earthquakes in Sind were not so severe but fissures and geyser-like holes in the Badin and Moghulbin caused a layer of dead fish to appear off the coast at clifton. A tidal wave was recorded near the town of Sindree in the *Rann* of Cutch in 1903. Mysterious sounds are sometimes heard by natives near the hot springs of Laki and other places in the hill range, and occasionally shocks are felt even at Karachi. But as stated above, the effects are localised and not so severe or far-reaching as those of hydrography in the Indus basin, which I shall deal with presently.

Although there is a large number of hot springs found in Sind, it is not possible to trace them to active vulcanism.

4. *Hydrographical Changes :*

(i) Unstable water-table : Snid is notorious for its meagre and highly variable rainfall. While there are peaks in the rainfall curves of great floods, there are also many years of droughts when the water-table falls very low. On the other hand, in certain restricted areas of sand belts, there is water logging and lakes are formed, so that not only does agriculture suffer but complete villages are destroyed. In the drier parts of Sind, where the water level falls as low as 400 to 500 feet, there are hardly any permanent villages in existence.

The hydro-isobaths within the Barrage area show varying depths (3 feet to 30 feet) not only in different parts but also in different seasons and in different years, the concentration being only possible along the river bed or along the canals. Outside

the Barrage area, the water-table fluctuates much more.

(ii) Unstable Hill Torrents and Springs: In Kohistan, there are perennial springs on high ground which suggest artesian conditions. Some of these are hot-water springs, which attract religious people who have built temples and mosques near them. At times it is difficult to say who first established these temples, Hindus or Mahomedans, e. g., at Mangho Peer and Laki. These springs are devided into (a) perennial and (b) seasonal. Prominent among the former are the Angai, the Naing and the Bandhni in the Johi and Sehwan Talukas. These spring-fed channels form some of the beauty spots of Sind, like oases in a rocky desert and the peasants take advantage of them even in a crude way, e. g., "Just above the village (Naing) the stream descends into a cascade which is harnessed by a water wheel for grinding flour and other cereals."

Some hill-torrents are seasonal and are only in full swing during the rains. Others are the Khenji, the Nari, the Gaj, the Makhi, the Salari, the Buri and the Baran. Although they flow for a limited period of time, their force is very great and the discharge is plentiful. Many of the surface streams in Kohistan are thus dry for the greater part of the year, but within their valleys there are deep-seated springs which supply water to some of the larger settlements.

(iii) Unstable Lakes: While there is such a great diversity in the depth of underground water supply, even in such a dry region there are lakes, which are of two kinds (1) Fresh water lakes, (2) *Dhands* or salt water lakes. Many of these do not exist to-day, but there is no doubt that in the past on the shores of these there were settlements, and even to-day, besides the numerous *Dhands* in the Thar-Pat Section, there are villages in which the chief occupation of people is the collection of salt from the salt lakes.

To-day the only large fresh-water lake in existence is the

unique lake of Manchar - which regulates the drainage of the right Indus bank. This must once have been a wider lake, as is proved by the presence of the Aral river, which now has a duplicate character, viz., flowing into the Manchar Lake in the flood season and into the Indus river in the opposite direction in the off-season. There must have been other lakes in the valley, but they are now no more in existence and cannot be located anywhere in Sind, e. g., the lake, crossed by Alexander while going over to the western branch of the Indus, which was 'of great extent and received its supply from other waters in the neighbourhood.'

Again some lakes mentioned in the *Chach Namah*, such as lake Gujri and lake Sangrah, deltaic lakes of Arab and Sumra days, are no more in existence - so also the lakes, such as that near old Hala - have disappeared through sedimentation, as all oxbow lakes must ultimately, one day, disappear.

(iv) Unstable Rivers: Hydrographical changes in surface streams and rivers are the chief causes of the unsettled population in the province. Sind is notable for the fluctuations in its river courses which form and silt up their branches, and for the formation and drying up of deltaic lakes and consequent changes in human settlements.

The main river systems in the region are :

(A) The Hakra-Wahinda System (Modern Eastern Nara) and

(B) The Indus system.

Both these rivers, and most especially the latter, have left marks in old courses or channels, viz., *Dhoroes* or deep depressions, 6 feet to 12 feet deep and from 50 feet to 100 feet broad with which the valley is covered, e. g., neighbourhood of Nasarpur. These dry channels are converted by man in some places into canals.

That there were these two distinct river systems existing in Sind in the past is recognised by some British geographers. After the Arab conquest, they were together called 'the Mihran of Sind'. Human settlements followed these rivers and every change in them caused disturbance in village life, water supply, and transit facilities.

(A) The Hakra-Wahinda System : As regards this system, which is now largely dried up and of which the lower part is now converted into the Eastern Nara canal, many theories are advanced by various authorities. The conclusions drawn by them are confusing, some of them having depended upon unreliable historical records or upon traditional tales from Iranian and Arabic sources. The archaeological department has done little in the way of extensive search or exploration of these long chains of ruins along its banks which, if dug out properly, would throw much precious light on the ancient history of the Sind and the Punjab.

The hydraulic data, which would be derived from so valuable an inquiry of this nature, are not available except those for the Barrage area, provided by the Department and Research Division of the P. W. D. of Sind Government. There is no doubt that it is a stream with a well-cut bed in the alluvium and without a large delta, which such an extensive river is expected to form. Beyond the latitude of Sukkur, it had little silt to deposit in the valley. How this river system has dried up, is worth investigating here.

There is no doubt, and Oldham is our authority on the point, that before the formation of *Khadar* alluvium in recent geological times, the Jamna flowed westwards through some channel such as the Budhi Jamna (Old Jamna) or the western Jamna canal, and to a certain extent fed the Hakra or Wahinda. From this source a large volume of water was made available for the whole of the desert tract, north and south.

During Vedic times, however, the Jamna and the Ganges were praised in songs together. The Sarasvati, one of the Ambala streams, then being fed by hill torrents, predominated. How the course of the Jamna was diverted eastwards, it is impossible with correctness to say. It may be due to the silting up of the channel, or to the capturing of the river, such as did Chambal, as suggested by Whitehead, in recent geological times. Some sort of river piracy by the Ganges or even self-piracy is also suspected.

At the same time, it would be incorrect to say that the present Jamna contributed to the waters of the Hakra, because the change took place in geological times, while the name Hakra is a recent one. Mr. R. D. Oldham writes : (Letter dated 1-3-1933: Llandindrod Wells) "Your difficulty is a natural one, but in saying that it seemed very impossible for the Jamna to have contributed any part of the waters of the Hakra, I was referring to the river of later times which was known by that name. The earliest record of this was in the 8th Century, if I recollect aright, and it is not likely that there was any natural overflow of water from the Jamna so late as that. At an earlier date when the Jamna did flow westwards, it probably followed much the same course as that of the Hakra in later times, much the same in fact as that suggested by Whitehead's map, - but in those times of which there is no historical record, the name of Hakra is not likely to have been in existence." This, then, settles satisfactorily a part of our problem.

The next question concerns the Sutlej. The Ambala streams are a logical continuation of the Hakra as a number of ruins along the whole line show; but whether or not the Sutlej itself flowed into the Hakra is a matter of great doubt. Classical writers have mentioned only four Punjab rivers as tributaries of the Indus. The Sutlej has not been separately named.

Mr. Whitehead has endeavoured to prove from hydraulic

data that the Sutlej could not have swung through such a long distance as 60-70 miles and flowed into the Hakra until recently. Raverty and Vincent Smith, however, showed that there was no difficulty in the way of the Sutlej having once followed an independent course into the Hakra.

Col. Minchin and Mr. Barns suggested the same; but the map drawn by them shows that there were chances of an overflow of flood waters from the Beas-Sutlej into the Hakra across the plains, e. g., in 1871. This situation must have been more favourable when the Sutlej flowed further south. In the alluvial tract of Bahàwalpur State there are numerous deep depressions, showing signs of deserted river beds and therefore of a connecting link between the Punjab and Sind. Some of the Ambala streams, those towards the north, even now flow from the Siwaliks, close to the Sutlej gorge. During the flood season and the year of maximum snow fall, these Ambala streams, above Sirsa and Bhatnir, must have come into contact with the Sutlej flow. Besides, the hydraulic data of recent years obtained by Mr. Nicholson in the Punjab must have been much affected by silt and sand in recent times. There is, no doubt that some of the Punjab rivers, viz., the Upper Indus, the Jhelum and the Chenab have westered.

We may, therefore, naturally expect at least a portion of the Hakra waters to have been derived from the floods of the Sutlej, when it flowed further south. When all the rivers arrived at the stage at which they are at present, and when the Ambala streams were also reduced in size owing to the accumulation of silt and sand, the Hakra dried up completely and the land, now called the Thar desert, became barren.

No doubt the connecting dry channels between the Hakra and its feeders in the upper reaches are now lost, being covered up with silt and sand. They were shallow, ill-defined beds, even split up into several collateral channels. But the deeper

and degraded channels of the Hakra, lower down and within the region of our investigation, still remain and are clearly noticeable throughout Bahawalpur State, and then, with a short break, also throughout the Thar and Pat divisions of Sind, known as the Eastern Nara.

The next point: Had the Eastern Nara anything to do with the Indus ?

First of all, let us settle the question about the real nature of the Hakra or Wahinda.

Considering the matter physiographically, the Hakra seems to be a distinct, moderate and perennial river system flowing round the corner of Bahawalpur and Sind almost parallel to it. It is a de-grading stream, having cut a channel of its own, now known as E. Nara and quite unlike the mature type of aggrading Mihran or Indus. The Indus itself did not flow through the Hakra valley. That is why no other river but the Mihran came in the way of Chach and Muhamed b. Kasim on their way from Alor to Multan. Nor was even the Sutlej mentioned by them. No doubt in this case also the flood waters of the Indus then flowed eastwards and past Alor through the old gorge into the Hakra. They did so recently before the opening of the Sukkur Barrage. Had the Hakra not dried up because of the failure of supply to its upper reaches (see above), the process of depositing silt and raising its own level by the Indus on the one (west) side and that of excavating its own channel on the other side by the Hakra, would have resulted in a sudden breach of the Indus into this low-lying channel, the Eastern Nara. As it actually turned out, and as the process of westering was continued in its upper basin, the Indus or the Mihran grew at the expense of the Hakra and the result was that the former river was deviated to the west and once for all it left the gorge of Aror entirely dry in exchange for that of Bakhar.

It must be noted that any historic changes in the course of the Indus have taken place suddenly and not gradually, and this is quite in conformity with the law of silting up of the valley, already referred to.

When this event actually took place is difficult to determine. Most probably it was in the 14th. Century A.D.

It is argued that the date of the Hakra drying up must be between 1151 A.D. and 1226 A.D., because the last mention of Aror was made by Al Idrisi in 1150 A.D. and the first mention of Bakhar is in 1226 A.D. This is not a very reliable method of fixing a date for a change in the river courses, because the Bakhar fort might have been re-built from sheer political necessity, because Alor was then so much exposed to external invasions, and for about a century or so there may not have been any Arab writer after Al Idrisi to include Aror in his geographical treatises. It must not be forgotten that Bakhar has been in existence since Greek times. In all probability, the change in the Indus river course through the Aror gorge took place in the 14th. century A.D. and it was about the same time that the Hakra dried up and the famished Nara was left behind. There is historical evidence to be taken into consideration. The Sumras were driven into the Hakra valley by the conquering Arabs of Mihran. They ruled at Muhammed Tur, now in the desert tract, from 750 A.D. to 1351 A.D. After the devastation of their territory which followed the drying up of the Hakra, the Sumras changed their capital to Thatta and Samui. When the Sumras had gone, the Sammas became the masters of Sind. They, too, ruled at Thatta from 1351 A.D. to 1521 A.D., when Shah Beg Arghun finally defeated the Sammas and rebuilt Bakhar with materials from the ruins of Alor, so that the destruction of the latter town was complete by that time.

(B). The Indus System: Regarding the Indus system there is so much literature in Oriental languages, and so old and

strange are the traditions, and so great are the wanderings of the river that it is difficult to give a detailed reconstruction of the sequence of events. It is possible to put together a concise account of the historical records of the Indus and of its tributaries and to check these with the physiographical features of the basin, and then to draw some definite conclusions.

The Indus was called 'The father of the rivers' while the sacred Saraswati of the Aryans was the 'mother'. It is mentioned in the *Zend-Avesta*, the *Vedas*, the *Purana*s, the *Mahabharata* and the *Ramayana*. Arab geographers grew eloquent over this river and called it the Mihran *Darya*. Strabo, the famous Roman traveller of the 1st. century A.D., mentioned Sind as the frontier country of India, and the Indus as the boundary between Iran and Hindustan. This unique river was famous as a great trading centre for foreign nations with India, and also as sacred for bathing, and efficacious in curing the diseases of the natives.

This river-valley concentration of population seems to be the earliest in India, and the people who were first engaged in cattle grazing, later established themselves in villages and towns on its banks, serving also as a river post. At the same time, the Indus has been the most erratic stream of the whole of northern subcontinent and we cannot say with certainty whether there is a square yard of land, between the high ground on the west and the easternmost course the river took, that has not at some time been scoured by the Indus bed.

An aggrading river in Sind with a long course of erosion and the transportation of material for over a thousand miles in its upper reaches, it wanders over the plains, raising, by its own silting, the level on either bank and then suddenly breaking away without warning into low ground on one side or another. There is rejuvenation, no cycles of erosion in the valley but great vicissitudes of the river channels in various ages. Sir Richard Burton said: "As regards the ancient course of the

river Indus, infinite has been the speculation and theorisation, the dissertation, the argument, and the contradiction upon this much vexed subject." It is only by examining some concrete instances such as the one mentioned in *Chach Namah* about the river at Alor, flowing by in the 8th. Century A. D. and also the relics of the great civilisation discovered at Mohenjo Daro and other ancient sites, that one can be certain about the courses which the river took at different times.

In any case, the Indus could never have wandered on higher ground, i. e., the contour of 250 feet on either side at any time of its career. Between these limits, there is no doubt that the river flowed in the different positions which I shall now discuss.

Broadly speaking, it is possible to indicate the course of the Indus to some extent for the following periods:

I.	Late geological period:	Post-Tertiary
II.	Prehistoric period:	Prior to 3000 B.C.
III.	Greek Period:	4th. Century B.C.
IV.	Arab period:	8th. „ A.D.
V.	Middle Ages:	12-13th. „ A.D.
VI.	Kalhora-Talpur period:	18th. „ A.D.
VII.	British period:	19-20th. „ A.D.

During the last hundred years, geographical information regarding the Indus, especially the vagaries of the growth of the delta country etc., has been gathered in detail, but for all the previous periods it is found to be meagre and unerliable. Where historical references and archaeological ruins are not available, it is proposed to rely on the physical conditions of the valley in the preparation of Sind's historical maps.

I. Late geological Period: The Indus in late Tertiary times formed the lower part of the Indo-Brahm or Siwalik river, which

flowed westward from the region of the Assam hills along the foot of the Himalayas, carrying the combined waters of the present Indus, the Ganges and the Brahmaputra, and then turning from the Potwar plain directly south, ultimately fell somewhere into the sea now occupied by Kutch-Kathiawar. This is now confirmed by the faunistic (fish-fauna) data recently gathered. This region appears to be a part of the subterranean ridge along the submerged gorge of the Indus, in continuation of the Aravallis on one side and the coral attols of Laccadive and Maldive on the other, discovered by the Murry Expedition of 1933.

II. The Prehistoric Period: The next trace of the Indus can be secured from the location of prehistoric sites, such as Mohenjo Daro, about 8 miles W. of Chanhu Daro, about 20 E. of Narujo *Dhoro* and 25 miles E. of the present bed. The river must have supplied the necessary stimulus for settlement on both its banks. The difficulty arises as to when, for example, the Indus flowed past Mohenjo Daro and when past Narujo *Dhoro*, at present some 30 miles apart. We know that the floods in Chanhu Daro were more disastrous than in the former places. The only feasible explanation therefore is that when the main body of the river flowed in the neighbourhood of Narujo *Dhoro* and of Chanhu Daro, a branch of it now nearly coinciding with the Western Nara, supported the population on the Mohenjo Daro side. Subsequently, the main river channel left the former sites and for a certain distance, occupied the channels of its Western branch allowing the Western Nara to branch off much higher than is the case at present; or it may be that the difference between the ages of the two cities is great, and the Indus swung from one side to another to feed both places at different times. In either case it must have passed through the *Dhoro* Mohenjo, as I have named the easternmost branch lower down. The maximum distance through which it can have oscillated in Upper Sind is estimated

to be 30 miles.

III. The Greek Period: It is impossible to follow the course of the Indus in very early historic times due to the lack of any records. Darius the great had the river surveyed by Scylax, but there are no archaeological or historical proofs to enable us to plot its course in the 6th. Century B.C.

As we approach the age of Alexander, two centuries later, we find some historical references to indicate the nature of the drainage, e. g., his oft-mentioned town, Patala, where the bifurcation took place, and the two ports, eastern and western, were situated. While the former lay at the end of the Gharo branch opening into the Gizri creek, the latter must have existed at the end of the Western *Puran* as far as the Kori mouth. The problem of fixing Patala at the head of the then existing delta can be solved by accepting the theory that the Indus in Sind in historic times has westered, under Baer's Law and Parker's Law, so that the right bank of the upper cusp has been constantly under attack. I have, therefore, given Patala its approximate position about 33 miles S.E. of modern Hyderabad. The lower cusp, forming the delta proper, can be imagined to have rested directly against the southern boundary of Kohistan as the positions of Barbariko, Krokala and Alexander's Haven would indicate. The Western *Puran*, opening into the Kori creek, must have formed the third side of the deltaic equilateral triangle according to Nearchus. Since there is no mention of another stream made by the Greeks, the Hakra must still have flowed independently. The port of Bakhar is mentioned in the Periplus, so that at least a portion of the Indus must have flowed here too.

IV. The Arab Period: The hydrographical conditions at the time of the Arab invasion are more clearly marked, the information found in the *Chach Nameh* especially being very valuable, as regards the 7th. Century A. D. and later centuries.

In Lower Sind, the river had already opened out its curve, forming the excellent port of Debal on one of its branches in the growing delta, while the main Indus taking the curve further towards the west, still flowed past Aror, which was on the west of it as is mentioned by the chroniclers. "Dur (Alor) is situated on the banks of the Mihran which runs to the west of the town." The physiography of the region shows that the whole of the Indus river could not flow through the deserted gorge of Aror, now lying east of the town. A side branch of it, or the flood waters of the parent river, must have flowed past the old Hindu capital, and another side branch flowed past Bahmanabad (Mansura), further south through the *Dhoro Puran*. The flood waters of the Sutlej in the basin, and other Ambala streams then fed the Hakra, which still flowed in much the same way as before, through the desert.

Majumdar, while exploring the region, has also pictured the Indus in Arab times as under :

"An old bed of the Indus, which is very well marked, falls on the way to Sakrand near the ruined fort of Mir Nur Muhammed. It is immediately to the west of the fort and runs North to South for a considerable distance; an eminence in the middle of the bed, which looks like an islet goes by the name of Lidhar-Jo-Daro. It is not however of any archaeological importance. This bed is supposed by the elderly people of the Sakrand Taluka to have been the continuation of what is popularly known as Sohnijo-*dariya*, probably identical with an ancient course of the Indus, traces of which can yet be seen in the Kandiaro, Naushahro, Nawabshah, Shahdadpur, and Sinjhoro Talukas of the District. Whether this is the same as the Mihran of the Arab geographer cannot be definitely ascertained. But it is not improbable in view of the fact that the Mihran has been described as flowing in the vicinity of Bahmanabad (Mansura) near Dalor in the Sinjhoro Taluka in

the 8th. Century A.D. A portion of the old Indus bed, no doubt another link of the same Sohnijo-*dariya*, was subsequently visited by me at the village of Pijaro Naich 11 miles to the north-east of Naushahro and to the west of the road to Halani."

The lower loop channel of the Indus, connecting it with the Hakra, was probably the same connecting river shown in Raverty's maps, 3rd. and 4th. Transitions, and passing by Bahmanabad.

V. The Middle Ages : The post-Arab geography of Sind is largely connected with the growth of the delta, the establishment of deltaic ports and the settlements along the banks of the Mihran, shown in the earliest maps of Sind by Arab geographers, Istakhri, Ibn Haukal and others. In all these maps a loop of the Mihran, referred to in IV above, is shown, which includes the famous town of Mansura, after which the whole district is named. In those days only the two districts of Mansura and Multan were prominent. The river by this time, had already assumed the bed in Upper Sind now occupied by it, but below Sehwan it had not yet settled down, the main stream still flowing eastwards. Then in the time of Ibn Batuta (14th Century A.D.) the sea receded from the port Debal, and Lari Bunder came into use, as it had a better harbour. Later, Thatta became the capital of Lower Sind, under the Sumra and Samma kings. The population of this part of Sind grew following the migration of the people from the Hakra valley, which had dried up. According to Haig, the Kalri, the then western-most branch of the Indus, was in existence, as Thatta was established on its bank.

Although there were changes taking place in Lower Sind, Sehwan and Bakhar in the north still remained well populated, and the invasions of the Delhi Kings were generally directed towards these centres.

Attacks from Delhi continued during the regime of Moghul kings and emperors - the first to visit Sind being Humayun. It appears that the land between Umarkot and Thatta was then fertile and the easternmost branch of the Indus, the *Sir*, must have flowed through this tract in the middle of the 16th. century.

The establishment of Shahbunder by Mirza Isa Tarkhan about the year 1555 A.D. clearly points out a further change and extension of the delta, and on this account, and owing to the lack of easy communication, the centres of government in Upper Sind were getting out of control. Bakhar was actually besieged and taken by Akbar's army. The march of the Imperial troops through Sind, in 1591-1592 was past the towns of Bakhar-Sehwan-Lakhi-Hala-Nasarpur, (then 65 miles S.E. of Sehwan) and Thatta, thus showing the probable course of the Indus towards the east of the present bed. They saw the sea at Moghul-bin, also suggesting the limit of the coast and inlets of the sea existing at the time.

VI. Kalhora-Talpur Period : It is because of the detailed historical information available for this important period in the growth and evolution of Sind that we are on surer ground as regards the 18th. century A.D. The change which took place in 1758-59 was particularly remarkable, in as much as it made Ghulam Shah Kalhoro establish Hyderabad as the capital of Sind in preference to Nasarpur, which became dry further east. The *Ren*, about 70 miles long, and the main Indus channel extending up to 100 miles and watering a large part of Sind, dried up. The south-east curve of the river took a westward turn and, at the same time, the Phuleli channel became the principal branch of the river, during the 18th. century A.D. This helped the establishment of Hyderabad a few miles south of it. Thus the Indus westered still more in this quarter until it finally fell into low ground to the west of modern Hyderabad, leaving the Phuleli dry for the Pinyari-Sattah.

The growth of the deltas was also marked by the appearance and disappearance of the river mouths; the Baghar and the Sattah were the two main navigable branches. The Cutch earthquake of 1819 broadened the Kori creek, and the Kukaiwari and Khedewari creeks appeared.

So, while the river went on westering, its branches towards the east became drier and drier, e.g., at first the *Dhoro Puran*, the Phuleli-Ren, the Gungro, and lastly the Pinyari *Sir* became dry in turn. The distance between the two main branches was also greatly reduced and the mouth of the river formed by the two principal branches became narrower.

VII. The British Period: During the last hundred years the Indus has not shown any great change in its upper course, although its actual bed is found to be swinging from left to right and right to left year by year, e.g., the oscillations below the Bakhar gorge since 1900, plotted by the Indus River Commission in their Records. It is shown that the channel is permanently fixed only for about 3 miles below the gorge and not more. In the middle of Sind, the river cannot wester any more, as it now rests against the high ground of the Kohistan region.

In the deltaic area evolution is continuous, though slow, and old channels are sometimes reopening. After Shahbundar, Keti Bundar came into use and now both Shahbundar and Sikhi Bundar, have been re-opened. The two principal branches, the Ochito and the Haidari, are pointing south-westward, which is the present direction of deltaic growth. There are now some 13 mouths of the Indus traceable, the principal being Pitiani, Hajamro, Tarshion, etc.

The greatest changes in the drainage of the land during the British period are in connection with the Sukkur Barrage project, whereby over 5000 miles of the main canal works have

been constructed out of only about 500 miles of the principal river course available in the region. Consciously or unconsciously, many of the old river beds called *Dhoroes* have been thereby absorbed. The final shuffling of population is now going on in Sind.

Such is the history of the Indus and the Hakra-Wahinda and other river systems throughout the ages, and of the settlements that rose and fell on their banks.

SUMMARY AND CONCLUSION

The lower Indus basin (Sind) has afforded facilities for some of the earliest human settlements in the Indo-Pakistan sub-continent, although it is an unstable land, with an unstable population, depending chiefly upon an unstable water supply. It is a land also of changing river courses, changing lakes, changing coastline, an advancing delta, intensely weathering tertiary rocks and accumulating sand. Even the sand-hills of the desert are changing as the winds blow during the year. The region again is in the neighbourhood of the danger zone of Northern sub-continent, and is unique in its numerous hot springs. There is a possibility of climatic variation as well, and of gradually rising level and alluviation. All this means instability for human life.

Floods were the greatest menace to human habitations, Mohenjo Daro itself being thrice abandoned on this account. Again and again, people tried to resettle on mounds higher up, the Indus left its channels, and a whole river, the Hakra, got dried up in the Pat-Thar section. Thus towns and villages often vanished.

This chapter has been based on a detailed study of :

(1) Geomorphology, e. g., (a) Aggradation by the river and aeolean agencies, (b) Erosion by external agencies, (c) Flood

menace, (d) Tectonic changes, (e) Growth of the delta, etc.

(2) Hydrographical changes, e. g., (a) Unstable water supply and water table, (b) unstable springs drainage, river piracy, etc., (c) unstable lakes, and (d) unstable river channels.

(3) Other changes in human settlements, due to political causes, etc.

SUMMARY OF RESEARCH ON HYDROGRAPHICAL CHANGES IN THE PUNJAB AND SINDH

Date of Research	Author	Method of Research	Result and theories put forth
1. 1871	Major General A. Cunnigham, Director Archaeological Survey of India in the 'Ancient Geography of India', Calcutta.	Archaeological	The Raini, Sotra, Chitrong were different from the Sutlej and met the Indus above Aror. The Eastern Nara - old bed of the Indus. Bifurcation near Jakrao into (1) the *Purana* flowing S. W. past Hermetelia, Brahmnabad, past Patala (Hyderabad ?) and then turning S. W. into the Guni once more to meet the main stream; (2) the S. E. stream flowing past Amarkot and meeting the other

				branch in the south near Wanga Bazaar. The combined stream then passed through the *Rann* of Kutch into the Kori mouth.
2.	1874	Sur. Gen. C. F. Oldham in the 'Calcutta Review' Vol. L I X. "The Sarasvati and the lost River of the India Desert", J.R. A.S. 1893	Historical	The Sutlej flowed into the Hakra, till the time it met the Beas westwards, owing to silting up of its bed. The Hakra and the Eastern Nara continuous, called Hakra *Dhora*, flowing independently till 13th. century A.D. through the Sind desert into the *Rann* of Cutch. The Indus has flowed westwards near Sehwan at least since the 8th. Century A. D.
3.	1875	'Nearchus' in the 'Calcutta Review' Vol.LX	Historical and Physiographical.	The Sutlej did not flow into the Hakra but westwards into the Indus near Rohri. The Jamna flowing westwards might have fed the Hakra. Marut Bredha, a mythical river, was the 'Lost River.'

4.	1886	R.D. Oldham, Director Geological Survey of India, in the 'Journal of the Asiatic Society of Bengal,' Vol. LV, pt. 2, No. 4	Geological, Physiographical and Historico-Geographical.	Supported C. F. Oldham's views. The Indus never flowed into the E. Nara (Hakra), but has kept westwards. The Hakra an independent river, though some times fed by the Sutlej positively and also the Jamna probably in recent geological times. Only the flood waters of the Indus flowed into E. Nara.
5.	1892	Major H.G. Raverty, in the 'Journal of the Asiatic Society of Bengal' Vol. LXI, pt. 1, No. 3	Historical and Traditional.	Two different river-systems meeting together above Aror into the Mihran of Sind : (1) The Indus and its four tributaries (without the Sultej), and (2) The Sultej - Hakra System. Five transition stages are shown after the Arab period. The Sutlej westered to meet the Beas. The Indus ultimately grew at the expense of the Hakra. The Mihran at first flowed past

				Aror and through the E. Nara.
6.	1904	Col. Minchin and J.W. Barns in the 'Punjab State Gazetteer', Bahawalpur, State. Vol. XXXVI-A	Physiographical	The physiography of Bahawalpur State suggests that the Jamna may have fed the Hakra through Ghaggar. The Hakra bed was too narrow to carry the Sutlej waters. The Indus and the Punjab rivers have westered.
7.	1924	W.H. Arden Ward C.I.E. in the 'Scottish Geographical Magazine,' Vol.XL.	Geographical	Westering tendency of the Punjab rivers. The Sutlej, a tributary of the Hakra and E. Nara. The Jamna may have fed them too. He also suggests a climatic change.
8.	1929	Henry Cousens, Supt. Archaeological Survey of India, in 'Antiquities of Sind.'	Archaeological	Differs slightly from Raverty. The Mihran flowed into the Hakra below the Punjab confluence. The Hakra had two branches: (1) the Western, which when it left Alor, flowed into the Mihran, and (2) the Eastern Nara. The

				Mihran, an important unfordable river between Alor hills and the present Indus in the Arab times. The Western branch of the Hakra left Alor after the Arab conquest and still later cut through Sukkur hill in 1758, an important Indus change.
9.	1929	M.R.I. Khan (Ph. D. London). Thesis, Mss.	Historical (Persian and Arabic)	The Hakra a tributary of the Indus, not the Sutlej nor the Jamna. The Eastern Nara, an old bed of the Indus. The united waters of Indus and the Hakra, Mihran. The Hakra dried up about the middle of 13th Century A.D.
10.	1932	R.B. Whitehead, ICS (Retd). 'Indian Antiquary,' Vol. LXI.	Hydraulic data study.	Rivers like the Sutlej could not oscillate for 70-80 miles—rivers governed by levels. The Jamna may have flowed eastwards. Possibility of the reduction of rainfall etc., as a cause.

CHAPTER X

THE LINES OF COMMUNICATION

INTRODUCTION

One of the potential problems of the geography of Sind is that of communications. No province in the sub-continent, least of all, Sind, can thrive without the necessary lines of efficient intercourse within the region and with the neighbouring lands. The toy bullock carts, excavated from Mohenjo-Daro indicate that even the people of pre-historic times, living in Sind, knew the value of free communication and indigenous transport.

The various conquerors of Sind followed the course of the Indus river, prevailing in their days, and established their own routes throughout the districts. The Arabs crossed the Mihran by their special devices of boat-bridges, while the Imperial troops of the Moghuls chalked out their own trunk roads even through the desert, which were disused soon after their downfall.

Even before the separation of Sind from the Bombay Presidency, the people clamoured for good roads and railways, the benefits of which were unfortunately denied to them for centuries. Year after year, the District Local Boards made pointed references to the quite inadequate means of transport in Sind, in their addresses to the Governors of the Presidency. There was at one stage not one single provincial road, worth the name, throughout the region from north to south.

But with the opening of the Barrage, the problem became

keener than ever before; and one way, in which the huge irrigation system could be made a success, was by improving the system of railways, water-ways, roads and camel paths, with which the province was not well equipped. For, with the Barrage proving an engineering as well as an agricultural success, and the crops being doubled and trebled, economically Sind could not flourish unless the increased products were conveniently and rapidly transporated to suitable markets outside its boundaries. In fact, new markets had to be sought continuously in order to maintain this very rate of increase of the crops.

PHYSICAL CORRELATIONS

In connection with this problem, it is necessary to record some solid geographical facts, which must always determine the nature and extent of all lines of communication in Sind.

The total area covered by the whole province is 46,400 square miles, out of which nearly half is waste and unculturable land, in Kohistan, the Delta and the Desert Sections, which may not need urgent attention. The valley proper, to the extent of about 20,000 square miles, must however be traversed well by any means. Again, the population of Sind is largely rural. There are very few towns, only about 30, but thousands of villages which serve the cultivated and irrigated areas and upon which the potential wealth of Sind crops depends. More than a great railway in the interior to link up any large cities or industrial towns, Sind would therefore need a network of good and durable roads, even *Kutcha* or grass-covered roads for which some districts are well-known. It has been estimated that 60 per cent of the agricultural produce in Sind can only be carried by camels, while bullocks are required for ploughing the fields. Besides, after the perennial system of irrigation has been introduced, certain areas have got water-logged and *Kalar* soils are produced. What could be the best means of transport and what lines of communication would be required in various parts, these are the questions always to be solved first. In some parts

of Sind, the difficulties of relief are great; there is no soil, nor vegetation, no water available for any kind of transport in Kohistan or the desert areas.

In a country, which is spread over with a network of canals and water channels and which is, now and again, visited by floods, bridges have to be built by hundreds, and ferries are required for crossing and recrossing them.

The main artery of the region, the Indus, is an awkward river, rising irregularly twice a year, and continually changing its course from time to time. No stable engineering works can be built across it or in its neighbourhood without an elaborate system of river-training. The fall of the country being towards the south, the canals run mostly in the north-south direction, and consequently the communication would always be controlled by these water courses. In the desert area, there are *Dhands* or salt lakes, and such parts are even below the sea level, so that the paths throughout cannot be continuous but broken and haphazard. *Sar* grass, suitable to cover earth roads, grows well in many parts of Sind.

The delta of Indus, being low and marshy, there is no coastal road possible as in the case of, say, Gujrat and Deccan regions of the sub-continent. Here the traffic can only be by water, and cross channels are required to connect creeks and river branches.

At the same time, there are some favourable geographical circumstances, which could be taken advantage of, while establishing the required communications. The Indus valley is an aggraded one and nearly flat for the greater part of its length. Both roads and railways are easy to make, there being no tunnelling or levelling of the ground required. Luckily, the river is fixed at two points in its course through Sind, where it could be easily bridged, viz., at Kotri and Sukkur-Bukkar,

though at the latter place, on account of the gorge, only a cantilever bridge could be erected.

The rainfall being scanty, there is no possibility of continuous wearing and no necessity of constant repairs of the roads on that account. But as the bed of the river is some feet higher than the surrounding country, there are chances of heavy floods and consequent destruction of the lines. These can be avoided by *Bunds* and loops.

Along the whole of the Khirthar on the west, the danger of hill torrents is considerable; not only roads and passage ways, but the fields are ruined at times, though it is possible to make a good use of the hill springs in making roads, after the floods have passed.

Limestones and standstones from the rocks of Kohistan can be utilised as road metal. But it does not stand heavy rains or floods. The clayey condition of the former and the arenaceous state of the latter are ruinous. Fortunately, better kinds of road metal, e. g., quartz porphyry from the Jasai quarry very near the railway station along the Jodhpur Railway and Deccan trap in the Laki Range are also available.

Black *Kalar* soil, obtainable in some parts of the valley, forms a very good road surface.

The Khirthar mountains are folded, and in some convenient parts there are good passes in these barriers. These have been utilised by man as trade routes in the past, e.g., the Bolan pass for the Quetta-Seistan trade route, the Mula pass for the Central Persian trade route, and Lak Phusi for the Makran-Baluchistan trade route. There is also a fourth passage-way across the Hab, called the Arab trade route. It is possible to utilise the same passes for renewed communications with the plateau of Iran even in these days. Some lines of camel paths are also possible

through the fractured anti-clinal valleys of Kohistan and the valleys of sandhills in the desert.

LINES OF COMMUNICATION

Before the occupation of Sind by the British, there were practically no roads but only tracks and "mere banks of earth raised above the level of fields" etc. But now it is fairly connected with Makran, Baluchistan and Afghanistan on the west and all parts of the sub-continent on the north, the east and the south.

(1) *Camel Paths:* These camel paths exist in the Kohistan area, generally running east-west and communicating with the passes in the mountains. They lie roughly in the elongated valleys in the sedimentary rocks, which get weathered soon. In the Karachi district, these paths converge towards Thano Bula Khan and proceed to Shah Beg, Amir Kot and, via other villages, to Sehwan. In Upper Sind, there are fewer paths and they are invariably destroyed by the hill torrents. These paths are inhabited by hungry hillmen or dacoits who on occasions suddenly come down, rob the villagers of their goods and escape through the circuitous paths back into the mountains. There is at present, no healthy intercourse between the adjoining territories, no regular caravans pass in and out at any time of the year. Even Alexander is supposed to have passed through one of these passes and Mohammad b. Kassim, another conqueror of Sind, had entered the province similarly. It is greatly desirable that these camel paths and the old trade routes should be re-opened, put in proper order, and systematic caravan services again introduced.

In the Desert Section, there is another labyrinth of camel paths running in many directions. No roads are possible through the sand-hills, but as they strike N.E.S.W. towards the south and almost N. S., as one goes to the higher latitudes, the paths get similarly oriented. Most of them cross at convenient

points, such as Diplo, Islamkot, Chhachhro, Umerkot, Khisar, Gudro, Chhor, Ranhu, Samarhu, Adhujowand, Bhojraj-jo-Tur, Baruji Wand, etc., and seek entrance into the neighbouring states of Rajputana (Jodhpur), Bahawalpur and Gujrat. There are no chances of improving the camel paths in this part of the Sind desert, except providing *Musafarkhanas* at the various stages and a better supply of water.

The camel is the only 'ship' of this sea of sand. The journey is generally made in the night, and some 120 miles are covered during the period of 10 to 12 hours. Drinking water is carried on camel back.

(2) *Water Ways:* It is true that the Indus has not proved to be a very good navigable river, its vagaries being many. But it has afforded facilities for navigation, since the times of Darius the Great and upto the introduction of the N.W. Railway in 1858. The Indus Flotilla existed since 1835, playing between Kurrachee and Multan, and even as far as Lahore; through the Punjab rivers, the native boats sailed successfully for many years. These boats, made of native wood, were small and flat-bottomed. At times they were substituted by floats of reeds or grass and were used for carrying timber, fuel, hay and agricultural produce.

After the Barrage, the navigability of the Indus has been further reduced, there being practically very little water running below Sukkur and as far as Kotri during the winter seasons. But when the gates are fully opened during the rainy season, the intercourse is renewed for some months. Below Kotri and through the various mouths and channels of the Indus, native Jetties ply.

Ferries are used for crossing the river at convenient points in the whole course of the Indus even at present, but the service is not well organised.

The Eastern Nara, after the opening of the Barrage and owing to the new Nara cut through the old Aror gorge, is now a navigable river, but there is no systematic service as yet introduced for the thousands of villages to which it would be a great relief. Forests exist on both sides of the Nara and a good trade can be established in their products.

During the monsoon season, even the Ghar and the Western Nara are navigable, and boats ply on them.

But for some falls, e. g., Tando Musti Khan, in the course of the Rohri canal which is no less than 208 miles long, good communication could have been organised on it.

The excellent geographical position of Karachi and the ever evolving state of the Keamari harbour have enabled Sind to take its place among the trading nations of the World, thanks to thc zeal and foresight of the Port Trustees. The fact that Karachi is actually nearer to Southampton by about 200 miles than Bombay, has made it the first harbour of the sub-continent for all European trade.

(3) *Railways:* As stated above, it is easy to construct railways in a flat plain like ours, but the consideration with the railway authorities is only economical. A thinly populated province could only have a single main permanent way with a suitable structure of light feeder railways.

Besides this, the maintenance of the lines is rather expensive owing to the river floods and frequent breaches of the river *Bunds*. Between Karachi and Kotri, for example, there are about 200 bridges under which the whole drainage of Kohistan is made to pass. The railway line on the right bank of the Indus is similarly dangerous due to the *Nais* or hill torrents from the Khirthar.

Owing to the difficulties of navigation in the delta country,

the railway between Karachi and Kotri was laid as early as 1857. Later on, in 1887, as the traffic increased and the line became a success, Sind was connected with the Punjab and onwards to Delhi, and a vast hinter-land was opened out thereby. Still later, in 1896, due to frequent troubles from breaches, the Kotri-Rohri line, on the left bank, was constructed, and the journey was also reduced by 38 miles. The Jodhpur-Bikaner Railway was opened in 1892. Thus, we have 1,191 miles of railway in Sind today as under:-

330	miles North Western broad gauge (double line)				
502		do	do	do	(single line)
228	miles Jodhpur metre gauge				
131	do	narrow gauge			
1,191	Total mileage.				

Of these, about 177 miles of railways run through the desert areas, while a little over 1,000 miles through the culturable ones, embracing about 20,000 sq. miles. This gives a ratio of one mile of railway to every 20 sq. miles of the valley, which in Mr. stubbs' opinion, "is adequately served by railways". Within the Barrage area itself the proportion is still more increased to 1:15, thus showing that "provision of railways has been on an even more generous scale".

However, as the Barrage lands are utilised more and more and difficulities of transporting crops to the nearest railway stations are keenly felt by the people, who also mean to develop some industries, various proposals have been made for the improvement and extension of the railways, at least in the more fertile parts of the valley. These are located in two districts especially, viz., the areas watered by the Khirthar, Shahdadkot, Warah and the Rice canals in the north western corner of Sind, and those watered by the Rohri, the Jamrao, and the East Nara

and their branches in Middle Sind. The increase of crops of cotton, wheat and rice, produced in these parts, cannot be dealt with without a suitable circuit of even light feeders. Two projects have, however, been sanctioned: (1) conversion of two-thirds of the present metre-gauge from Larkana to Shahdadkot into the broad gauge and continuation of the existing line, via Dodapur to Jacobabad, a distance of 83.90 miles, and (2) building of a metre gauge line (30 miles), connecting Khadro, on the Jodhpur Railway, with Nawabshah. A large sugar factory at Khadro will also be adequately served by this extension of the metre gauge and the desirable circuit round Mirpurkhas, Digri, Pithoro and Khipro will be completed in the Eastern Valley Section, in course of time. The conditions of the soil in these areas are such that no roads can be constructed as alternatives to the railway projects.

(4) *Roads:* The greatest development in the lines of communications in Sind should however be in roads. In fact, it is the most convenient and the cheapest way in which agricultural produce can be conveyed to markets or to the nearest railway stations.

I have already referred to the non-existence of any roads worth the name in Sind, before the British conquest. Sir Bartle Frere, who may be said to be the first to propose a programme of road-making in Sind, remarked in 1851 that there was "not a mile of bridged or of metalled road, not a masonry bridge of any kind, in fact, not five miles of any cleared road".

Old Roads: Some roads then came into being in Sind, so that till recently it had the following main lines of communication in the different districts with suitable stages or halting places and water supply:-

District	Main Road	Stages
Karachi	To Sehwan	9
	To Lakhpat via Thatta	11

Dadu	Kotri to Laki	6
Hyderabad	To Rohri	4
	To Umerkot	2
	To Rahim-ki-Bazar	6
Sukkur	To the northern frontier (for Multan) on the left bank of the Indus.	9
	To the northern frontier (for Multan) on the right bank of the Indus.	10
	To Jacobabad	3
Larkana	To Dadu	5
Nawabshah	To Hyderabad and Rohri	9
Thar-Parkar	To Nagar Parkar and Umarkot Via Mithi	9
	To Nagar Parkar and Umarkot Via Chhachhro	7
	To Umerkot and Sanghar	4
	To Umerkot and Sufi-jo-goth	3
	To Umerkot and Hyderabad Via Mirpur Khas.	4
Upper Sind	To Jacobabad and Kashmor Frontier.	7

As remarked above, the conditions in Sind are generally favourable to road making. Even the Report, made by Mr. Stubbs, shows the extreme necessity of making new and suitable roads and of improving the old ones already existing. He says: "If we judge from the experience of other undeveloped agricultural countries in the World, it may take generations before Sind can reap the fullest benefit from this magnificent (Barrage) Scheme, perhaps the finest of its kind ever built, if early steps are not taken to improve communication."

He recognised the existence of 9,930 miles of roads, only 134 miles of which having been metalled, and some 9732 being *Kutcha* Roads, he recommended the metalling of 585 miles of roads, (as feeders to railways), and 9,631 miles more for all purposes, to be repaired with brick pavement, *Kalar* soil, clay or *Sar* grass, at a cost of Rs. 776 lakhs in the first five years and Rs. 20 lakhs in the second five.

Problems of road making: Such an elaborate programme is also beset with inherent difficulties. The roads are mostly in charge of various public bodies (17 Municipalities, 8 District Local Boards and 61 Taluka Boards) with no great central control; half of the province is desert land; the railway lines have already occupied the main length of the valley and there can be no rail and road competition allowed; many roads lie below the level of the surrounding fields and get flooded frequently, bullock carts have to be small, and only hired camel transport is possible in the majority of cases. The cultivator is usually poor, his annual income being Rs. 13 per annum.

There are other problems of road-making also for the authorities to consider.

(a) The distances to cover important centres are vast; according to Mr. Stubbs, there are some 37 ginning factories, 11 cotton presses, and 265 rice husking centres in Sind, which have to be approached any how.

(b) The roads pass through clay belts and sand belts, hopelessly entwined, and the soils vary in chemical contents in all localities, e. g., black *Kalar* soil, though good for road making, gets slippery when wet, while light brown *Kalar* soil is satisfactory only when wet but gets cut up when dry. Similarly, efflorescent *Kalar* soil is bad with loose top and needs stabilising. Even the proportion of clay and sand varies in the soils of Sind. Those having less than 75% clay being considered to

be third class and quite unsuitable, unless moistened.

(c) There is deficiency in humidity in the air for the greater part of the year and consequently the roads get dried up and cut up under heavy traffic, especially in Upper Sind.

(d) Really good road metal is not near at hand but to be conveyed by rail for long distances and transhipped at Hyderabad.

A smaller and more modest proposal was required to be made in the beginning, and, therefore, Government appointed Mr. H. B. Parikh, I.S.E. as special Road Engineer for the purpose. Mr. Parikh had already made a scheme to construct 581 miles of trunk roads and 808 miles of feeder roads at a cost of Rs. 3,20,00,000 in 1927.

But in 1935-36 the estimate had to be reduced to Rs. 39.98 lakhs (since revised to Rs. 38.52 lakhs) only for improving 716 miles of roads, as earth roads, 43 miles of metalled roads to be asphalted, 76 miles to be metalled and asphalted, and 55 miles to be provided with brick paving, all to be completed in 5 years. Mr. Stubbs' proposals were improved upon by the District-Conferences and the Advisory Communications Board, Sind, after duly considering the relative importance of the roads in various districts.

Experiments on surface dressings with road tar, liquid asphalt, socofix, Shalimar tar, etc., have been already made, and the best ways of making cheap and durable roads have been found. Black *Kalar* soil has proved to be a very suitable coating in many places, and so it is utilised. Further research is necessary on the problem of stabilising the surface of *Kutcha* roads.

Where there is unsuitable *Kalar* soil, it is covered with an inch or two of socofix. When moisture is required for the protection of roads, it is supplied with hydroscopic salts, like

Cacl Nacl and mollasses. Experiments on "ponding" roads, as a protection against floods, have also been made. Earth roads are invariably covered with *Sar* grass, which is grown on the road side, in the best possible manner. As regards metalled roads for heavy trafflc, quartz porphyry from the Jasai querry and lime-stone from the Kathar querry are used, and the soiling and coating are suitably made as an experiment on the Hyderabad-Badin road with good results. With the establishment of cement factories in Sind, concrete trackways, about two feet wide, are also tried in some localities, where the soil is good and the cost of road making is considerably reduced thereby.

But Sind has yet to go a long way. Mr. Stubbs recognised in 1934 the existence of 9,930 miles of "roads", while the Mitchell-Kirkness report gave 12,600 miles as another figure. But of these so-called roads only 198 of miles were metalled roads, including 40 miles of brick-paved roads. Even a hasty soil survey of 1,739 miles, made by the Consulting Engineer, showed only 167 miles having 1st class soil, 256 miles 2nd class soil, 1,035 miles 3rd class soil, 8 miles *murum* and 255 miles *Kalar* (including 31 miles efflorescent). The preliminary estimate of cost in 1938 was nearly 31.4 crores of rupees for good trunk as well as feeder roads in Sind, but the Province's Public Works Department had to content itself with only a few lakhs a year throughout. There is no doubt that our resources are limited. But funds or no funds, for the betterment of our province and for providing it with decent minimum standards of civilized life, proper lines of communication must be provided within the Barrage area and without.

RECENT DEVELOPMENTS

The nature of aggraded lower Indus basin demands the railroad connections in a circular manner. No dead ends would be profitable. Among the recent developments in Sind, the following project is worth noting.

(1) Tando Mohammed Khan - Moghalbin Railway (B. G.) 69.49 miles.

A double suggestion can be made in connection with this project. To cover the whole of the area, to be commanded by the Lower Sind Barrage, it would be better to have a broad-gauge railway running from Badin to Mirpur Bathoro and thence to Sujawal and Moghalbin. From Tando Mohammad Khan to Badin, there exists a line already. The dead-end of Badin can be revived by connecting it with Mirpur Bathoro, which should be almost the same distance as from Tando Mohammad Khan to Badin. Actually the cost of this new railway will be almost the same, and at the same time it will serve the purpose of making a circular route in the whole Indus Delta.

An alternative proposal is to connect Jhudo on the Jamrao-Pithoro loop-line in the Thar desert with Badin and thence via Mirpur Bathoro to Sujawal and Moghalbin by the metre-gauge. This would also involve almost the same cost but would make the necessary connections between Thar-Parkar District and the Indus delta now to be commanded by the Lower Sind Barrage. Further towards the east of this zone, it is high time to connect Sujawal with Thatta, by a ferry-boat service of the same gauge as the railway whichever is constructed here, in the absence of a bridge over the Indus due to its vagaries, and onward to extend railway to Jhimpir, or Jungshahi on the N.W.R., so that the required circle may be completed. The Sind Assembly lately suggested that they should have their new capital on the site surrounded by the Makli Hills near Jhimpir and Jungshahi and not at Hyderabad, and so this scheme of connecting the Indus delta with Sind Kohistan by a railway can be expedited with profit. Even otherwise it will be a paying proposition.

CO-ORDINATION OF COMMUNICATION LINES IN WEST PAKISTAN.

This is a dry zone, not easily accessible in the higher parts

but having an elongated valley lying between two prominent deserts, Baluchistan on one side and the Thar-Rajputana on the other. Too little water is its weakest point, but the soils are harder, interspersed with clay-belts and sand-belts in the plains with small pockets of barren land. The river channels too are unsettled; the soft rocks, through which the rivers flow, carry an enormous quantity of silt and sand charges, and the banks are frequently eroded. The rise of water-level is sudden and enormous at times. The beds are also unstable and rise in level, century after century, due to alluviation. In fact, the whole hydrography of Western Pakistan is a changing feature. Thus, there are only a few fixed points in the river channels to allow crossings. The rivers generally flow in the N.E.-S.W. direction with converging tributaries and *Doabs* lying in between. These Doabs are very much canalised except the Sind-Sagar Doab, which lies in the Thal area. This Thal tract is marked by high banks shut in between Indus and the Jhelum-Chenab rivers. There high banks check the swinging of the river channels and, therefore, they have run dry with a good deal of accumulated sand and patches of *Reh*. At the same time, there are large areas of very fertile soil. The southern section of the Thal area is less fertile than the northern. It has actually a strong thirsty loam in the north, and sand rising into hillocks and ridges with some fertile pockets in low levels in the south. *Bhangar* (high-level) or older alluvium alternates with *Khadar* (low level) or newer alluvium in all such Doabs. Generally speaking, in the Indus Valley the pattern of natural drainage is of a swinging character, and so the water channels, and, therefore, the lines of communication show deep or shallow curves. In the lower Indus valley, which lies mostly in Sind, many such meanders or loops are found with changing river-beds and migrations, except the fixed points of Sukkur-Bukkur and Kotri. The attack is generally on the right bank in the upper parts of the valley and on the left bank in the delta

proper. The curves are deeper in the Sind Province to enable them to meet at these fixed points. Below Hyderabad, the delta is a constantly growing physiographic feature with unstable channels. There are dangers of flood in Sind twice a year, (I) due to melting of the snows early in summer, and (2) due to rains during the monsoon season. Even the river ports are unstable due to the changing mouths of the river and the growing delta, e. g., Shah Bunder and Keti Bunder, which were once flourishing ports, but are now silted up and are in disuse. The pattern of railways in this zone is, therefore, curvilinear.

In this whole region of Western Pakistan, the only stable and permanent seaport is Karachi. Fortunately, in this zone, some of the waterways and canals cut from them are navigable. There are a few mountain passes in the frontier region, allowing long routes from the provincial capitals in their directions. Increasing aridity in some parts, untouched by canal water, does not permit the construction of roads and railways and there are abrupt endings, if they are at all constructed. But now, as more and more land is canalised and irrigated after the lower Sind Barrage and its dendritic pattern of canal distributaries particularly, millions of acres of fresh land will be brought under cultivation. There are, so far, no great discoveries of petroleum or other minerals made in Western Pakistan, but when they are discovered, they will stimulate human activities causing new facilities of roads and railways to come into existence.

SUMMARY

The above analysis shows:

(1) In both Eastern and Western zones of Pakistan, a certain amount of river navigation can be and should be revived. Even in the Indus delta, in which the depth of channels is very low, improved types of shallow boats, permitting a draft of even 2 or 3 feet of water,

can be used. This would relieve the burden on some existing railways and the construction of new ones may be reconsidered.

(2) Roads and railways in the plain areas in both the zones are controlle by the natural drainage pattern,—roughly curvative or circular built in the Indus Valley and triangular or square in the Ganges delta. Wherever such patterns are incomplete, plans will have to be made to complete them.

(3) On both sides due to the furious nature of the floods and the changing hydrography, river crossings are few and far between, with the result that communication lines are disturbed, bridges are difficult to construct and maintain, and river training works are in great demand. Roads and railways have always to converge on a few fixed points.

(4) With the increasing flood control, the construction of new barrages and dams and more and more canalisation, more land will be brought under cultivation, demanding a further complex network of roads and railways.

(5) In Eastern Pakistan, in which due to the slippery soil and quicksand no broad gauge railways can be built, it would be necessary to duplicate the metre gauge railway at any cost. At the same time, in those parts of Western Pakistan in which the nature of the soil permits and in which there is increasing prosperity, the conversion of the metre or narrow gauge into the broad gauge will be a desideratum.

(6) But the greatest relief to the people of Sind, and its semi-desert parts, should be derived from airways.

Already the services of the Pakistan International Airways are available, from Drigh Road (Karachi) the gateway of Indo-Pakistan, upto the N.W. Frontier. A regular service to Baluchistan, Karachi-Hyderabad, Jacobabad-Quetta is also desirable.

CONCLUSION

Thus Sind, on the whole, is but fairly served by the different lines of communications. Much remains yet to be done. It is only when the most unaccessible parts of the region are made accessible by some means, when the transport of goods made as rapid as the growth of crops and industrial products, when the inhabitants are able to live a more abundant life, that the prosperity of the region can be fully and rightly gauged.

CHAPTER XI

INDUS VALLEY CULTURE.

THE USES OF GEOGRAPHY

The ultimate aim of all geographical studies is Culture. But there is no doubt that the most synthetic of all sciences, viz., Geography, has been left in the background. Physicists have fathomed the atomic world, chemists have analysed many drugs, geologists have peeped into the past epochs of the earth, and biologists have tried to understand the workings of the human body; but there are few who have put social values on all these researches and tried to know why and how Man behaves in a particular natural region and in a particular manner, and how and why a particular natural region has affected the whole progress of the people and their settlements. Where other Sciences leave off, geography must begin. Geographical science will easily offer an explanation of what has happened in the prehistoric or historic past. That physical problems are closely connected with historical and sociological problems cannot be denied. More than folklore, legendary data, even numismatic or archaeological evidences, it is the geographical landmarks that should be valuable to historians and sociologists, viz., river terraces, lake levels, silting and alluviation, deflection of lakes, the vagaries of rivers, etc.

The following diagram will show the comparative value of the various branches of Science and the right position of geography in the evolution of human knowledge:

PYRAMID OF KNOWLEDGE

Geography
(Sum-total
of
Sciences)

Biology
(Life)

Chemistry
(matter)

Physics
(Laws of energy)

Geology
(The Earth)

Astronomy
(The Universe)

Mathematics
(Fundamental Science of Numbers)

It is thus easy to understand how precious the knowledge of geography is for the welfare of human beings and what an important position it occupies in any scheme of education or scientific culture. Since geography scientifically synthesises the findings of other sciences, it gives a complete picture of a country. Geographers have even to help our economists to keep their feet on the ground. It was Henslow who persuaded Darwin to attend lectures on Geology, and these were helpful to him in making that far-reaching and wonderful discovery-"The Survival of the Fittest and the Law of Evolution." Similarly, this much neglected science of geography is a panacea for the evils that prevail in the world. It should at least help make people broad-minded and sympathetic towards one another.

The present deplorable condition of the world is to a great extent due to ignorance of geographical knowledge. Even the

world wars have taught the world more geography than any other events could do, so that it can be said that "The chief use of wars is to teach people geography." Upon the right knowledge of various parts of the world and the nature of the environment in which man is placed, depends the success or failure of any operations, on land, sea or in the air. It is, therefore, time geography was introduced as an important part of the military science. All nations must base their defence prepararations on the geography of their lands. Unfortunately for our country, our students are kept painfully ignorant of these vital factors; in Pakistan particularly geography must be of far more importance to them than other subjects, because the present position of world affairs shows an ever-increasing interdependence of one nation on another, and there is an ever-growing necessity to know the character and aspirations of peoples.

The map of the world is changing fast. What the world badly needs is collective security and indivisible peace without human hatred or fear of war. These objects cannot be attained without a proper understanding of the ideals of all nations. Pakistan must be a powerful member of such a union. Happy Mingling of Cultures should be the Aim.

The more we know about each other's outlook on life, based on environment, the better it is for all; since the more likely we are to come to an amicable understanding and friendly relationship. The same is true of all international and inter-communal relations. Contact of cultures in a congenial natural environment is likely to unify our diverse customs, languages, creeds and castes more than anything else. The law of assimilation helps the process everywhere. A good example of such a mingling of cultures in a congenial region is that of Javanese civilisation. "We find here," says Dr. A. A. Bake, "a People who having been under the influence of a different culture for a period

of centuries have been able to absorb congenial elements of that foreign culture to such an extent that the mass of the population is completely unconscious of the fact that there has been any foreign influence at all." Indo-Pakistan sub-continent, for example, has been enriched through Parsee settlements for well nigh fourteen centuries; and where other communities may measure their strength by their numbers in millions, the Parsees measure theirs by their pure faith and spirit and by their world known cosmopolitan charities performed as religious duties.

But to prove our theses more thoroughly, let us take the example of Sind, - The lower Indus Valley, - as a natural (physiographic) region, which has played a valuable part in the evolution of the Afrasian belt of civilisation and also served the Indo-Pakistan sub-continent as an antechamber for the passage of cultures through the valley and their further spread into its other parts. We shall deal with a few important points to show how much our civilisation owes to the historical geography of the "Provinces", and how much more we can do in present times to unify and harmonise our diverse cultures,–not by breaking Provincial boundaries and steam-rolling them all into a rigid and lifeless uniformity, but by accepting this radiant and life-stimulating diversity of the many-sided splendour that Human Culture always is, as a fact and as an asset, so that on the eternal and ever-enduring bed-rock of Nature's life principle of "Unity in Diversity", a firmer and more splendid edifice of human civilisation could be raised,–a civilisation in which innocent Nature and natural surroundings should play a vital part with the help of man.

THE AFRASIAN BELT OF CIVILISATION

Civilisation ensues where the struggle between Man and Nature for a civilised life is great. The environment of the atmosphere, hydrosphere, lithosphere, and even biosphere act as

powerful forces around man and help or hinder him to make progress in life. Such natural surroundings were suitable for human civilisation in Asia, which is indeed its first home. Here man received good stimulii for his material, moral, and spiritual evolution.

Properly speaking, it is the belt, now known as the Afrasian steppe desert belt, which is responsible for the various contributing cultures. It embraces such congenial regions as the Nile valley, the Aegean islands, the Jordan valley, the Euphrates-Tigris valley, the Iran plateau, the Caspian-Aral basin, the Indus valley, the Gobi region and the Yangtse valley. All these regions produced cultures peculiar to their own soils and climates and all of them have contributed to one another to produce human civilisation, off-shoots of which have found shelter in different parts of the world to-day.

Asia is a peculiar land of great elevation and conveniently flat, grass-covered depressions. It is, therefore, here that there are formed in it isolated regions, which were congenial to human occupation and culture, age after age. These centres of culture, -Egyptian, Cretan, Chinese, Chaldean, Babylonian, Iranian, Greek, and Indo-Pakistan–rose and fell one by one. Here in Asia as the natural forces went on working, sometime and somewhere in the Euphrates-Tigris valley, even the Garden of Eden was located, and here again in suitable epochs of human history, one after another the prophets came, beginning with Lord Zarathushtra who was the first in Iran to conceive the idea of unity in nature and oneness of God and the first to give a moral tone to religion.

Here in these trying regions, the prophets came to make man's life happy. The problem of problems for mankind always has been food and water. Where they could be found in abundance for the time being, one by one the lands were

occupied. From the food-hunting stage on the plateaus, when man reached the food producing stage of civilisation in certain valleys, a distinct progress was made by him. Where he found flint, fire was discovered as a result of an accidental clash of stones. This was the beginning of the Stone Age. Where metals were found in the rocks, one by one the different ages of copper, bronze and iron came. When land was sufficiently watered by rain or river in a valley, cultivation was started. Wherever such waters could be artificially carried to convenient distances, canals were made and irrigation begun, - a distinct advance in civilisation; and lastly communications were established to carry the food products from one place or region to another. In all these operations, it is established by modern geographers, the steppe desert belt was more favoured by Nature than other parts. Subsequent desiccation and accumulation of sand made even some of these regions unbearable, and migrations took place.

It is at some critical time in the evolution of this belt that the Indus valley came into its own, and wave after wave of human beings migrated through the available mountain passes and settled here. Not daunted but rather stimulated by any natural barriers and obstructions, the settlers in the valley all struggled, and by their creative powers and ability to adapt themselves to the environment, produced a new civilisation, which was the result of a fusion of local cultures with congenial foreign elements from neighbouring lands.

CONTRIBUTION OF SINDHIAN CULTURE.

Here in the lower Indus valley, - itself a great gift of the sacred Sindhu, - the experience and inventions of a number of human races were pooled together in order to produce the very acme of civilisation. Let us first consider the physical factor which contributed to it.

Geographical Control in the Indus Valley: In search of more grass, food and water supply, man came and settled here from very early times. (Witness Mohen-jo-Daro, 2700 B.C). He made efforts to understand the regime of the great river, to control its periodic floods, to erect *bunds*, to survey and cultivate the flooded areas and to make the best use of his leisure hours.

Like Egypt, Sind too became "a mother of mechanical arts." Here the soil was systematically renewed by Nature herself, by means of the silt carried by the river every season. Fertility and productivity were thereby maintained. The rhythm of the crops and daily life was developed, the inundations being good stimulii for labour in the fields. On such a fertile plain there were good chances for peaceful settlements or colonies which grew on both banks, and the river remained a unifying factor. It helped to unite the interests of the cultivators to whichever class or religion or society they belonged. Thus a single government dispensing singular justice was established for controlling the supply of water at different places and for different seasons. Co-operation was willingly given for the same reason. Deprived by Nature of older rocks and precious minerals, Sind had to communicate and trade with distant parts of Asia to import these for her progress. Up and down the Indus, the people moved carrying their goods; there being no rapids, as the valley here is in aggraded state, there were no serious barriers to travel and communication. The land gradient is low and so the canals could be cut in any direction and to any distance, e. g., the Rohri canal, cut from the Indus as a part of the Sukkur Barrage project, is over two hundred miles long and passes through very barren districts.

Sind forms the lower flat-valley plain of the Indus lying between two barren areas, the Khirthar mountains and the Rajputana desert. The soil is rich and the river delta

is a growing one in the valley. The climate is hot and dry in summer with very little humidity. The region lies in a critical corner almost on the border of the tropics and the temperate zone. All this marks agriculture as an ideal profession in this valley with no danger of loss of arable land, with the prospects of the growth of natural vegetation belonging to both zones. It is, so to say, the half-way house for both kinds of vegetation to take root and grow.

This is the result of man's "well-directed and concerted efforts to adapt and exploit the natural resources." Sind is a good example of a comparatively small but partially protected plain. Its mountain barriers are good and the desert segregates it further from other enemies. They help it to develop its individuality.

Value of Obstacles: At the same time, Nature has put certain obstacles in the way of man's life in this region. The mountain barriers were not complete, and through the few but convenient passes as well as from the sea coast came marauders and others from time to time to disturb the peace. No definite frontier policy could be fixed by any Government for this reason. The climate was rigorous, very hot in summer, though cool and bracing in winter, with a very small and variable rainfall. This made the people hardy but dependent on chance, and consequently fatalistic. The bed of the river in Sind is on a generally higher level than the surrounding country. This caused floods to rush into the fields and to destroy them. The people had perforce to be vigilant to gain mastery over these destructive forces. The majority of the ancient cities were probably destroyed by such floods e. g., Mohen-jo-Daro. Underneath the sand and clay, they are buried with their precious treasures, strata by strata, which archaeologists can now excavate for the benefit of our modern historians. What better proof and data could we furnish in Sind than these buried cities to the destruc-

tive powers of these floods ? The river delta is growing continuously and so the distributing branches change. There is no permanent channel, and therefore no permanent settlements are possible within the delta or on the uninviting mangrove swamps of the coast line. The changing river itself swings widely through a territory nearly 30 miles on either side and its bed is constantly changing with no towns permanently fixed on its banks, except one or two on rocky promontories, e. g., Sukkur-Rohri and Sehvan. The underground water-table is also unstable from one season to another and from one end of the region to the other. Wells, dug deep for water, are therefore unreliable.

In the Tharparkar and neighbouring areas, a whole river, the Hakra, has dried up and left the land barren, only to be re-watered by the Nara canal in recent years. In summer, the solar heat is intense and the very houses of the inhabitants are made to rotate, so to say, to face the windy direction e. g., windsails of Hyderabad. In such a dry land, the scarcity of domestic animals is also greatly felt. This circumstance has forced the people to take care of such crude creatures as the donkey and the wild horse, as best as they can. The camel, however, is the greatest discovery of the Desert, - an excellent example of adjustment to environment for food and water. So in such semi-desert conditions, man had an opportunity to evolve himself well to whatever community he belonged at the outset. Human ingenuity has to be constantly exercised here, and such virtues as self-preservation, industry, courage and endurance were developed, and human perfection was attained thereby.

"It is the unfavourable conditions themselves," says Professor Jean Brunhes, "that determine the perfection of the human establishments. The effort that man puts forth to exploit the land is a factor both in what he wishes to do and in his triumph

over difficulties which the land imposes upon him. The more difficult and refractory the earth shows itself, the more the ingenuity. Under the direct influence and the pressure of imperious necessities, man sometimes succeeds in attaining a rare degree of perfection." Indeed in Sind the natural forces were powerful and varied: they could produce a fusion of cultures of a very high order on that account.

Clash of Cultures in the Indus Valley Region: With the periodic desiccation of the Iran plateau and the growth of sand, the people, who could not get sufficient water, food or space, escaped through the mountain passes and caused havoc and destruction in the valley for the time being. From early prehistoric times, the Chalcolistic culture penetrated into the Indus valley from the west. Here came the Vedic Aryans to disturb the peace and prosperity of the people of Mohen-jo-Daro. The enterprising Iranians sought this valley also for building up their empire. The Budhists, Afghans, Mongols and Turks took their turns, as time went on.

The adventurous Greeks closely followed the Iranians who had navigated the Indus for them for the first time. The virile Arabs next came along the Makran coast and made good use of the river and the sea-board. Sorely disappointed with the trying conditions in the desert, even the Rajputs sought a shelter here. From the neighbouring soft lands of Cutch, Kathiawar, Gujrat, entered the soft people, the descendants of the races who had inhabited these parts in former ages and who were used to peaceful pursuits. Later still the enterprising Europeans, Parsees, and Christians have come to trade. Thus together some sixteen classes of people have settled in Sind.

The result - a Clearing House of Cultures: Thus Sind became a veritable cauldron of human passions. Raids, piracy and plunder were common. One race tried to crush another, and

the other to suppress and to destroy a third. But Nature's immutable law of indestructibility must prevail everythere, and from this great conflict of ideas, ideals, wants and differences, there has sprung in Sind a culture which can be called unique. Its very language, Sindhi, is a composite one - Sanskrit in origin and Arabic in style. It has produced a single class of cultivators called *Haris*, both Hindu and Muslim, to whom the question of crops or water supply is quite common in the Region. Their music, daily life, even dresses and manners, are similar. The best product of Sind is its *Sufism*, quite unique in the realm of philosophy. There are saints who command the respect of both communities in the Province; there are few castes and fewer creeds; and comparatively few folk belong to the depressed classes. The Sukkur Barrage has solved the problem of perennial water. Through the arteries and veins of its canals and distributaries, this heart of Sind now pumps its water of life for all the inhabitants regularly and rhythmically day and night. Thus Sind is rejuvenated by progessive Man, and the obstacles and difficulties of Nature are vanishing. Permanent settlement can now be made in Sind. The best gifts, which the rulers have at long last given to the Province, are agricultural prosperity and political autonomy.

It depends upon the people themselves to keep eternal peace and evolve themselves further. It is a peculiarity of the population of Sind that there are few large cities. It is mostly a rural population of moving villages, which in suitable irrigated centres alone turn into an agglomeration of villages. For this reason there were established several capital towns in the past dynasties, each as it suited them. The British on account of their seafaring character, founded the cosmopolitan city of Karachi which being a good harbour, has now grown into the Federal Capital of Pakistan, while Hyderabad the erstwhile capital of Sind, has a population of only about three

Lakhs mostly of the advanced and well-to-do class. The healing product for all the people however is their mystic poetry of Shah Latif, Sachal and Sami, leading to a kind of spiritual unity among them.

What Sindhis lack today is education - technical education more than all the rest. Today, Sind like every other land with semi-feudal economy, is full of short-comings. A land such as this, constantly tries the patience of man. Its evil practices of cattle-lifting, abduction of women, dacoities and murders, ill-treatment of the poor *Haris* by rich and unscrupulous Zamindars and the phase of unstable Government, these are occasional flashes of man's self-expression, constrained as he finds himself in the shackles of decadent economic and social pattern of life, that otherwise denies him spontaneous and full existence as a free and self-disciplined citizen. In a region, in which the forces of Nature are so dynamic and social pressures and compulsions so restrictive and suffocating, such out-bursts are bound to take place. They can be got rid of by a carefully planned system of education reflecting its geographical environment and Social requirements. To make the Barrages a greater success than they have proved themselves to be, there must be a basic redistribution of land, better and more judicious sharing of the waters among cultivators and a better sense of administration at every stage of Government machinery, both Provincial and Central.

Concluding Remarks: The Cultural boundaries of Sind have been pushed back by civilized man. Clannishness, from which other regions suffer so much today, has been avoided. A Sindhi claims himself to be a Pakistani, nay, cosmopolitan and humanitarian, since his culture has been enriched and made unique by influences, from distant parts of Asia, and later like the rest of the sub-continent, from countries in the Middle East and Modern Europe. He has in turn, significantly contributed to the culture of the peoples with whom he came into contact through trade,

commerce and by other means. Thus, a Sindhi does not suffer under any sense of cultural exclusiveness or chauvinism. All the same, he is legitimately proud of his own culture, which though so catholic in content, remains yet distinctly local in form - and in this, human actions and natural phenomenon both have played their mutually interacting role. An endless interaction through centuries of conditions, physical and human, internal as well as external, has served to make Sind what it is - a veritable crucible of cultures; and this very absorbency and unitive power of its mind, synthesising diverse elements of human culture and incorporating different influences of world's great civilisations, has blessed it with a personality at once superior and modest, universal and selfsome.

A Sindhi is thus a philosophic, strong, forbearing, tolerant, patriotic and peace-loving individual. Like the great river which is Sindh's life-spirit, the Sindhi farmer has learnt to receive and to give gifts. Sindh's cultivable soil is itself foreign, in as-much-as it is drifted by the Indus system from the gigantic mountains and dropped into the valley by floods for the poor *Haris* to reap their crops from. As long as the river inundations were irregular and unstable, the farmers remained fatalists, believing in *Kismet*, but now with the assurance of a stable water supply from the world's most stupendous irrigation system, they have adjusted their farms and their homes. There is now a regular rotation of crops, *Rabi* and *Kharif*, throughout the year. No longer are the people idle or jobless during the year; only circumstances and .natural environment made them so in the past. The sudden unprecedented migrations of the population after partition and the influx of Muslim refugees from different parts of India are bound to produce marked changes in the culture and civilisation of the Indus valley as time goes on.

An impartial and scientific study of regions like Sind in the

Indus valley as a whole reveals many valuable correlations and phases of our varied cultures, and with such a study, people of different regions will cease hating one another and instead live self-contented within the flexible boundaries of their own areas - proud and self-possessed, yet full of esteem and admiration for the achievements of neighbouring brotherly peoples of Pakistan, the great common homeland of them all. Such useful work awaits to be done by the University Departments of Geography in the Faculties of Arts as well as Science. It cannot be delayed if we want to live in peace and to have a good Government of our country by our own people; it cannot be denied to our youth, since upon this rests their proper education, and upon such research, done on a co-operative basis, also depends the safety and peace of the whole civilised world.

CHAPTER XII

CONCLUSION, AND THE FUTURE OF SIND

Whatever may be the political divisions and sub-divisions made of the country - of the sub-continent of Indo-Pakistan or of Pakistan in particular -, one aspect of Sind is that it is a perfect geographical region - the lower Indus Basin - a Unit of distinct physiographic characteristics resulting in a kind of self-determination, which has helped her to produce the typical Sindhi Culture for centuries. Like Poland, however much the external forces play upon the region, it survives and goes on producing that Culture, even if the population is shuffled and reshuffled by the impact of time.

Sind is blessed by nature in many ways. She has been endowed with a healthy environment, a rich alluvial soil, a perennial supply of fresh water and a virile, though peaceable and submissive race. Its very location in the critical corner of the Indo-Pakistan sub-continent is also very advantageous. Lying between two prominent deserts, - the Thar-Rajputana on one side and the Baluchistan desert on the other, at the very entrance of the Iran plateau - it has well stood the ravages of time. Its barren sedimentary rocks with very slight mineral content, even excluding petroleum so far, its rigorous climate, and its hazards of floods, earthquakes etc., have rather helped to produce an organic life peculiar to itself. Its plants and animals resemble African types due to the latitudes into which it falls. Its human history is long and chequered, and yet

it is remarkable. In recent years man has endeavoured to conquer nature and to utilise the natural resources as fully and as well as possible. It is no longer 'An Unhappy Valley' as it was once called, but it has formed on the contrary a precious part of 'The Granary of the East'. The various classes of people who entered the valley by land or by sea, have helped to produce a kind of culture unknown in other parts of Asia. The mighty river Indus has been its best friend and supporter. The soils too have stood well against the pressure of the ages. Prosperity for all time has been secured through the Sukkur Barrage, with the Kotri Barrage now running a close second, soon to be followed by the Gudu Barrage, for conserving the water resources of the lower Indus basin into which the province has fallen by chance. Sindhi industries are typical of the Indus valley, and their craftsmanship is proverbial. The products have attracted the nations of the neighbouring areas for long and they will no doubt stand in good stead for the Sindhis - old and new.

Sind has also to some extent profited by Partition. Although deprived of its stable and well-built harbour of Karachi, it still possesses a very profitable coast. The *Muhajirs*, several lakhs of whom have now migrated to Sind, will no doubt contribute to its future welfare. Urbanisation so badly needed in the past, is now seriously taken up by the present administrations.

Always a land of contrasts, Sind has benefited all who have come under its charm and its sway. Change is the order of the day everywhere in Sind, and even the human settlements have been changing. The contrast is great in its treeless hill sides, but green valleys, its dry surface but abundant underground water supply, its hot summer but cool winter, its rainless monsoon but perennial irrigation canals, and its rough and stumble sort of existence but peaceful and contented life with resignation to the divine will. Its geography has indeed compelled its people to adjust their mode of living. They are a good example of the

law of "The Survial of the Fittest."

MORE WEALTH AND WELFARE

Even Sindhi plants and Sindhi animals are, over long periods of time, adapted to the local conditions of climate and soil in this unique region. Their power of endurance and their numerous varieties and breeds are the best proof of this. They can stand the rigours of climate and other aspects of the environment and evolve themselves. Man being a more mobile and delicate animal must take time to acclimatise himself and to obtain the best fruits from nature. The *Haris*, particularly, have had to pass through the ordeal more than the other inhabitants, as they have to deal directly with nature and her whims.

The *Haris* are, indeed, the pillars of the population and the real hope of Sind. Hard work is the criterion. The severity of the weather and the irregularity and scarcity of the water supply made them at first fatalists and indolent. Now that nature is slowly being conquered, the balance will be on their side and ultimately they will prosper. It is with very great interest that movements of the "New Sindhis" will be watched. The share that they can give and the services which they can render in the further evolution of the province, will be incomparable to those rendered by previous settlers, as the demands of Pakistan are great and rare on the side of industries, both cottage and large-scale.

Further deterioration of the soil by human negligence is dreaded. All decrease in production per unit of surface must be arrested. The yield has to be restored side by side with more irrigation by means of a proper marriage of crop production and animal husbandry. If both are well integrated and the fertility of the soil is assured, Sind will find more wealth and welfare than it has hitherto been able to do.

CONCLUSION

Sind is actually older than it always appears to be. From the debris and dust of ages, it seeks resurrection again and again and endeavours to be ever young and new. Nature, too, helps it in its attemps to do so, - the ever-changing river courses and watertables, ground levels and lake levels, hill-springs and inlets of the sea, sand hills and *Kalar* soils, floods and other catastrophes, annihilate human settlements and recreate them in their new garb and surroundings, as the hand of man has intervened. Human adjustments were badly needed in the Indus valley. The mighty river has yielded and fallen at his feet, so to say; Barrage aftar barrage perennial irrigation, mechanised agriculture, planned industries and political security must assure the population of Sind that they will be settled into happy and prosperous life once for all.

The personality of Sind, produced by such an interplay of man and nature, further stimulated by the newly acquired freedom, must make it a stable, rich and integral part of Pakistan.

Appendix I

A NOTE ON KARACHI

INTRODUCTION

Karachi is now the capital city of the Young Dominion of Pakistan. Although physiographically it still belongs to Sind and the lower Indus basin, it has been the "Glory of the East", the "Liverpool of India and Pakistan" and the "London of the East". It rose to be the first Air Port and the third Sea Port of the undivided India within a brief period of 100 years, having been established by Sir Charles Napier in 1843. It is a queenly city, grown to be Sind's metropolis amidst the innumerable and unstable villages in the province, the only other city worth the name being Hyderabad, the old capital of the Sindhi Mirs. No other city in India or Pakistan has had such a brief history but at the same time such a rapid rise and such an extraordinary growth.

A mere fishing village, it grew, at first, in the days of its Hindu traders, to be a town of "low mud hovels and tall mud houses with flat mud roofs", mud being plentifully found in the adjoining Lyari valley; then during the last four decades, it had quite a phenomenal growth with over 600% rise in population. The census of 1941 disclosed its strength to be 3,86,655, and just before the Partition in August 1947, it boasted of thousands of palatial buildings and a population of nearly 4,25,000 which, due to the influx of the refugees and others from the sister Dominion, is now said to have increased to almost 15,00,000 people,

with a very solid Muslim majority. As the capital of Sind, it covered in its extended form an area of nearly 72 square miles as far as Mauripur on the west, the trans-Lyari quarters on the north-west, a few scattered hills on the north and north-east, the dry Malir river valley on the east and the south-east, and the Manora Island, Oyster Rocks and the Clifton and Ghizri Beach on the south. With the establishment of the capital of Pakistan in the city, it has been contemplated to build Greater Karachi, a metropolis enormously extended to cover an area of over 20,000 acres, so that there may be established in this locality a capital city, worthy of the world's largest Muslim State.

Karachi owes its greatness to its unique location at the extreme west-end of the Indus delta (latitude 24°51' north and longitude 67°4' east), and its most favourable geographical situation as a centre of three great continents, Europe, Africa and Asia, - some 200 miles nearer to Southampton and 400 miles nearer to London than the city of Bombay, besides commanding the Arabian Sea and the Indian ocean. It is actually 4,903 miles distant from the air-fields of London and 9,792 miles from the city of New York, by air, taking hardly 24 and 48 flying hours, respectively, by the direct routes.

Among its many attractions may be mentioned the following:

There is a harbour, partly artificial and partly natural, and protected by the solid rock of Manora at the very mouth of the Lyari. It has a vast and rich hinterland, covering not only the whole of the Indus Valley but also parts of the neighbouring Iran plateau. It took the British engineers some 60 years to build the harbour and to have Karachi declared as a first-class port in 1907. Before the last World War, the sea-borne trade was nearly 52 crores of rupees. The import and export trade of Karachi exceeds 22 lakhs of tons at present, while the en-loaded and off-loaded air mails come to over 100,000 lbs.

Although it lies on the outskirts of the Thar desert on the one side and the dry parts of Baluchistan and Makran on the other, it has an equable climate throughout the year, due to the influence of the sea and the south-west monsoon, and in spite of very scanty and variable rainfall - the eastern and western depressions causing cyclonic storms and the frequently varying weather conditions during the year.

It has a very wide scope for expansion almost on every side, except towards the sea coast in the south, so that it gives an excellent opportunity to the city's town-planners to provide for zonal planning with several satellite towns around the parent city.

In spite of the province being largely Muslim in character, Karachi has all along been one of the most cosmopolitan cities in the East. According to the last census, it had actually a Hindu majority of population. With the influx of the refugees a new impetus has been given to the city's growth and culture.

Most of the Karachi-ites, both new and old, are engaged in trade and business, which the harbour and the hinterland richly afford. It is a pointer to an all Pakistan civilisation, so urgently needed in our country today. It is expected that from the clash of various cultures, which have now gathered together after the partition of India, Karachi will rise higher and higher. With its door opened widely towards the sea, the World's men and materials can still go on entering. Thus, it is likely to remain fresh and rejuvenated for all future times.

Karachi at a glance: The accompanying map of Karachi will help the readers to see the city at a glance and to keep their bearings in some of its crowded parts. The two dry river beds, one on the left and the other on the right, are the most prominent land-marks. The city is actually sand-wiched between

them. The area shaded dark marks the cantonment limits with the Keamari harbour to its extreme south-west, while some of the well laidout and fashionable parts of the city are in the Civil Lines and Saddar Bazar, in which areas English is spoken side by side with Urdu and Sindhi. Most of the new colonies are established like a ribbon growth on both sides of the Bunder Road, which is the most important and busiest thoroughfare in Karachi. Other main roads lead the visitors to the suburbs and satellites, forming the framework of Greater Karachi, which is now in the making. The fringes of hilly Kohistan just touch Karachi in the north, which circumstance has helped the city with the building materials, stone quarries, water works, high level reservoirs and other sites. A vast open space is noticeable towards the north-east of the city, so that there is good scope for expanding the city particularly in this direction.

Greater Karachi: It has been planned to have the Federal Capital of Greater Karachi to cover 566.8 square miles of land within a radius of more than 20 miles, including the present Karachi City, and its suburbs, such as Mauripur, Hab, Mangho Pir, Korangi Creek, Malir, Landhi, Manora and the neighbouring islands.

The following 54 *dehs* or villages are also included in this area: Mann, Allah Bano, Lal Bhakhar, Mendiari, Chattara, Moachh, Gabo Pat, Mochro, Gund Pas, Mal, Garhi, Motan, Orangi, Karikali, Pir Mangho, Halkani, Hab, Bund Murad, Jam Jo Chakhro, Sor Jani, Babrano, Gujhro, Okewari, Drigh Road, Dih, Ibrahim Haidari, Phihai, Sharabi, Drigh, Safuran, Songal, Biti Amri, Taisar, Nabgan, Mokhi, Bijarhi Buthi, Tahming, Tor, Doozan, Thado, Mahran, Thano, Landhi, Gangiaro, Rehri, Khanto, Sanhro, Khakhar, Malh, Dasano, Chhano, Bazar, Khar Kharo, Konkar, Nara Thar and Shah Murid.

The boundaries of Greater Karachi have been fixed as under:

"On the west the boundary of Karachi is the river Hab from the point where it falls into the sea upto the northern boundary of *deh* Bund Murad; from there it proceeds southwards and eastward, following the southern boundaries of *dehs* Mithaghar and Mahyon; thence in the northern direction along the southern boundry of *deh* Allah Phihai; then along the western and northern boundaries of *deh* Shah Murid; from there proceeding in the south-eastern direction along the eastern boundaries of Narathar and Konkar upto *nai* Langheji; then along the southern boundary of Kathor turning towards and following the western boundary of *deh* Amilano touching *nai* Malir; thence along the northern and western boundaries of Chuhar upto *nai* Sukhan; from *nai* Sukhan along the southern boundary of *deh* Darasano Channo, the eastern boundary of *deh* Khanto upto the railway line, then to the west along the railway line upto the western boundary of *deh* Bakran upto the sea shore; and from there Karachi is bounded on the south by the sea (including the islands of Manora, Bhit, Baba, Bunkar and Shamspir), upto where the Hab falls into it."

A grand suburban railway is also projected, to have a circular route, from Malir Halt Station, crossing the Lyari and passing by the village Goli Mar and through the Municipal sewage Farm, again crossing the Lyari river near Sher Shah village and passing through the Mansfield Import Yard to rejoin the Main Railway Line. This branch railway will serve the newly designed Sind Industrial Trading Estate, which has been located at a distance of about three miles from Karachi city and Mauripur on Manghopir Road.

Thus, Karachi has now been transformed to be the Federal Capital of Pakistan with the original city, surrounded by the new colonies in which lakhs of refugees have been rehabilitated group by group, and also enlarged with a large number of industrial concerns and factories worthy of the new State. Its

physical relations with the rest of Sind, however, have been maintained. A plan to establish quite a new Capital city has also been made near about Gadap, within the federal area and about 20 miles from the original city.

HISTORICAL BACKGROUND

Karachi has no great past to boast of. There are no ancient glories and no great historical associations here; no gigantic monuments, no ruins, no long stories of peace or war. It is a child before the hoary old cities like Mohenjo Daro, Harappa and Delhi. The oldest archaeological site nearest to Karachi is at Orangi on the banks of the Orangi River, still flowing in a famished form through a portion of the Mangho Pir hills about 6 miles north-west of Karachi. But although Karachi has too little history, it can be said to have made sufficient progress as the trend of its past achievements show.

The pre-Arab Period: Quite a contrast to this is the history of the province of Sind. It has the pride of possessing the oldest pre-historic city in the Indian sub-continent, called Mohenjo Daro, which belonged to the Chalcolithic period and is perhaps not less than 5,000 years old. It possessed a kind of Dravidian culture and developed what is now known as the Indus Valley Civilisation. It was typical of a river valley civilisation and many precious archaeological relics have been found in it, some of which are now kept in the Pakistan National Museum. Pottery, cotton clothes, metal works, copper ornaments, toys, etc., were well-known. The trade must have been both by land and by sea and the Indus river with Iraq and Iran, via the Persian Gulf. The Persians under Darius the Great conquered the whole of the Indus Valley later on. It was he who got the river surveyed for the first time under Skylax in the 6th. century B.C. and gave a great stimulus to its trade by sea with the neighbouring countries. When Persia was later on con-

quered by the Greeks under Alexander in the 4th. century B.C., Sind naturally came under his supremacy. Several new settlements were made on the banks of the Indus, such as Patala, at the very apex of the Indus delta. After his great victories, Alexander is said tó have returned via Las Bela, while his navy under Nearchus had to halt, due to the onslaught of the monsoon, somewhere near Karachi, a place which is spoken of as "Alexander's Haven". This is perhaps the earliest historical reference that we can get about Karachi. "Krokola" is another Greek name, with which Karachi is identified by some scholars. Sind next came under the influence of the Tartars, the White Huns and others during the later centuries. Hindu kings were then ruling at Alor, near Rohri, the ancient Hindu Capital of the Province. Sind and Hind were the two divisions of the sub-continent according to the "Chachnameh". The Sindhis, as a rule, are a soft people, of the soft soil, never worrying to give resistance to the numerous invaders but always succumbing to them, so that when the Arabs actually arrived in 711 A.D., Sind fell an easy prey to Mohammed b. Kassim. He, too, brought his men both by land and by sea and used the old Makran trade route for the army, and the Arabian sea for the navy. Debal, not Karachi, was then the most flourishing port some miles towards the east beside the Indus delta. After defeating the Hindus in several battles, the Arabian sea established new cities like Mansura within a loop of the Indus and strengthened their authority in this newly conquered territory.

The Indus river being most unstable and the periodical floods being terrific, Sind had several capitals in the past, viz., Patala, Alor, Brahmanabad, Mansura, Nirun, Hyderabad, Thatta, etc., all changing capital cities in a changing land. There was no permanence anywhere. Even the ports on the delta of the Indus have changed e. g., Shah Bunder, Keti Bunder, Lari Bunder, and Ghizri Bunder. The Sindhis tried to establish some

reliable ports in the mouths of some of the rivers, e.g., Kharak Bunder, a river port on thc Hab being very prominent. But the trouble about these ports was that the river mouths were ultimately silted up and they had to shift their business from place to place until the arrival of the British who searched for a more reliable and stable harbour like Karachi on the coast of Sind.

Arab Influence: The Arabs were the first to introduce Islamic culture in Sind. Many natives were converted to Islam, including the Sindhi lords and kings. Their influence was the greatest in the formation of the Sindhi language of which the script is Arabic, while the vocabulary is largely Sanskrit. At once Sind became a muslim-majority province and has remained so ever since. The Arab influence, with its three great legacies of the Sindhi script, the Islamic faith and the Arab culture, went on for only three centuries; but for another thousand years and more, Sindhi Kings remained under the domination of the Muslim rulers like Afghans and the Moghals. Now and then some local chiefs declared themselves independent, as the nature of the country helped them to do so; for instance, the desert parts of Sind became refuge centres for many of them. The history of the province is rich with the folk-lore and Sufi tales of such dynasties as the Sumras and the Summas, who were Rajputs by descent but Muslim by faith. The Arghuns and the Kalhoras were the next masters of the province. It was during the time of the Kalhoras that Karachi was made a trade centre, and in 1729 when the merchants of Kharak Bunder on the Hab river had to seek another more accessible port, it received a fresh impetus from them. Karachi was ceded, later on, to the Khan of Kalat by the Kalhora Chief, but in 1795 the last native rulers, the Talpur Mirs, recovered it from the Khan.

The opening of the 19th. century saw Karachi to be the chief sea port of Sind. According to "Memoirs of Seth Naoomal Hotchand, during the first two decades there were several

ches of his firm in different places. In fact, about the year 1840, Karachi had quite a prosperous trade with Cutch, Kathiawar, Muscat, Bundar Abbas and even Zanzibar. Such a favourable position of the port naturally attracted the attention of the sea-faring British in 1843. After the defeat of the Talpur Mirs in the battles of Miani and Daba, the British supremacy was formally established in Karachi which was declared to be its new capital. "Too great a value," remarks R. H. Keneddy, "cannot possibly be placed on the possession of the harbour of of Kurachy, whether as a military and naval station or as a political and commercial city." It was actually the key of the whole valley of Sind and the Punjab, and of the approaches, both military and commercial, to Central Asia.

Contribution of the British: The British found in Karachi only a fishing village with a small mud fort and a ditch, called Kalachi-jo-Kun with two gates, one called the Kharadhar (a salt-water gate) facing the sea and the other called Mithadhar a sweet-water gate) facing the Lyari river. They then started developing both the harbour and the town. As has been remarked before, Karachi is one of the very few natural harbours on Sind coast, as the land generally rises above the sea level and above the continental shelf and almost all the rivers form their deltas, so that even the river mouths get quickly silted up. Only a solid protection and a safe anchorage were needed. Such was not the case with Karachi, when Sind was annexed by the British. The development of the harbour was undertaken by the Sind Government. Sir Charles Napier, the first Governor of Sind, took a personal interest in the Capital town, and in 1847 when he left Karachi, a granite monument was raised in his memory near the Napier Mole, which was the first attempt in the improvement of the Harbour. This monument is the most important historical relic in Karachi.

At first, the port afforded anchorage for native jetties only.

No vessel, drawing more than 10 to 12 feet of water, could enter the harbour safely. There were no wharfs for passengers or for goods. The following improvements were then made gradually: The Keamari Groyne, the East Pier, the Chinna Creek Bridge, the Manora Break-waters, the Ship Piers such as Merewether, the West Wharf, the Light Houses, the Oil Pier, the Dry Docks, until in 1917 the Karachi Harbour boasted of not less than 17 wharf berths and two moorings for outgoing vessels drawing nearly 27 feet at the lowest tide. Side by side with these, the harbour afforded a naval base and a seaplane base. The Lido was rapidly converted into a port of flying boats for the Imperial Airways.

The advent of the British gave a tremendous stimulus to the trade of Karachi, and the extension of the city was contemplated by them with the construction of the Civil Lines, the Municipal limits and the Cantonment areas. The prosperity of the trade was so great that it was said with pride that any adventurous men, who set foot upon the soil of Karachi with only a few coins in their pockets, would leave rich legacies behind.

A hundred years with Bombay: For nearly 100 years, Karachi and Sind were connected with the Bombay Government, the Bombay Army on their way to the Punjab and Afghanistan having conquered it at first. As such, both the city and the province were naturally neglected and remained backward. There was little progress in the province due to the seat of the Government being far away and the Commissioner-in-Sind, who actually ruled, having very limited powers. The cry for Separation from Bombay was raised by the people from time to time until 1936, when Sind became a self-governing province.

The most valuable gift of the British to Sind, apart from the city of Karachi, is the Lloyd Barrage at Sukkur, which was opened in 1932. It is the largest irrigation system in Pakistan

and has rejuvenated the land. Innundation canals have been turned into perennial canals. New roads and railway lines have been constructed. There have been bumper crops, ever since, of wheat and cotton in the cold *(Rabi)* season and of rice in the hot *(Kharif)* season, with the result that the Barrage debts of over 25 crores of rupees have been repaid by the Sind Government and even at present Sind is definitely a food surplus province. With the completion of two more barrages - the Lower and the Upper Sind Barrages - and the further extension of the canal systems and lines of communication, Sind is bound to rise still higher and grow more prosperous. All this means the simultaneous rise of the Karachi harbour and the tremendous growth of the city proper.

The expansion of Karachi during recent years has been haphazard. "It is a most irregularly shaped city, continuously undergoing changes," according to the Census Report of 1931, "having no fixed wards, a mush-room city ever expanding over a tract of sand, its edges submerged for extensive distances to different depths at different states of the tide." Now with the establishment of Karachi as the capital of Pakistan, it has been considered desirable to expand the city systematically. Only an up-to-date system of town planning can make it a healthier, more habitable and, to certain extent, even a great industrialised city. Every square yard of ground has to be surveyed, if it is desired to build, beside the present city, an imperial capital worthy of the newly-created dominion of Pakistan.

THE PHYSICAL AND BIOLOGICAL ENVIRONMENT

Physical Features and Geology: Low flat-topped hills and parallel or sub-parallel ridges devoid of vegetation, vast intervening grounds and dry river beds and other water channels are characteristic of Karachi's physical environment. Once belonging to the Tethys Sea, this land has risen from the great depths with the rising of the Himalayas, the last ripples of the surging

land having been marked in the Mangho Pir hills, the Clifton, Manora, Ghizri hills and the Drigh Road dome. Very low dips and gentle domes of the Tertiary rocks are an indication of petroliferous beds. The heights within the city limits ordinarily do not exeed 100 feet and gradually fall to 5 feet at Keamari. The rocks being soft and the climate being dry for the greater part of the year, there is the tremendous subaerial denundation of rocks and the simultaneous erosion of the coastline due to the stormy sea. Surface springs are generally found within denuded anticlines. Very few minerals of economic value can be secured in such a region, but lovers of geology will find their visits to the outcrops of these rocks amply repaid by the excellent sections containing Tertiary and post-Tertiary fossils, e. g., in the hills of Clifton, Pleistocene and Ploicene (Manchar) fossils; in the Ghizri and Drigh Road Dome, Miocene (Gaj) fossils; and in the Mangho Pir hills, Oligocene (Nari) fossils. Among the rock formations can be found the aeolian or crescent-shaped sand-hills, littoral and deltaic shell banks, the post-Tertiary conglomerate, the Siwalik sand-stone, the Miocene marine limestone affording good building stone and road metal and the inter-bedded clays of different kinds. Among the associated minerals are calcite found in the joint-planes of limestone, gypsum overlying the Gaj formations, pockets of lignite and some iron-stone in the Nari beds. Chances of manufacturing cement, bricks, tiles and alkali salts in Karachi are great.

The rise of levels everywhere is found, the sea having been gradually driven back, though at one time it made inroads and several islands were formed, viz., Manora, Keamari, Bath Island, Clifton, Ghizri and Oyster rocks, most of which are now connected with the main land. For this reason, the gently sloping Clifton beach affords some excellent paddling and bathing, while the high and eroded sides of the Bath Island are actually dangerous for swimming. The most interesting geo-

logical section is found at Mangho Pir, now only a hill 582 feet high but once an anticline with its dome not less than 3000 feet. high. It is now tremendously denuded by subaerial agencies, and the Orangi, a tributary of the Lyari, still flows through it. Due to a fault there are hot springs found at Mangho Pir, with the maximum temperature marked to be 126°F. But though Sind and Karachi are within danger zone due to the unstabte folded rocks in the Kirthar mountains, there is no real vulcanism found in the neighbourhood.

The soils are calcareous and heavy and to some extent also saline.

Natural Drainage: Karachi is far removed from the Indus; even its silt is drifted away from it towards the east by the wind and ocean currents. Except the Hab, there are no perennial rivers in the neighbourhood, and even the Hab forms a series of shallow pools for most of the year. The Lyari, with its tributaries, the Orangi and the Gujro, flows past the most thickly populated parts of the city. It is a menace to the Old Town, and ultimately falls into the Keamari area. The Malir, draining the Mol plateau in Kohistan, has the Mole and the Khadeji as its chief triburaries, supporting several villages. After their confluence, the river assumes the single name of Malir, which ultimately falls into the Ghizri Creek towards the east of Karachi. Rainfall being very scanty, these rivers are dry for the greater part of the year. They flow hardly for a couple of days during the season, but they are a powerful underground source of fresh water supply for the city. A branch of the Lyari, at one time, actually flowed through the crowded area of Old Town, the only relics now left being the Embarnkment Road and the Dhobi Ghat.

Climate: The climate of Karachi is, on the whole, very pleasant and bracing and is the most striking feature of Karachi's

natural environment. The temperatures are moderate, but the relative humidity is in excess in some months, so that the sensible temperature is actually high, - the warm air feels warmer and the cold air feels colder than it actually is. Otherwise, the sea breeze, for the greater part of the year, is a great boon, and acts like a natural fan to the inhabitants. The people have devised, in Sind, what are called wind-sails, many of which can be found in the Old Town. Naturally in a place like this, the dust nuisance is inevitable.

The mean monthly temperature at Manora varies from 56°F. minimum in January to 90°F. maximum in June, while at Drigh Road, only 6 miles inland, we notice the minimum temperature to be 50°F. in January and the maximum of 95°F. in June. The range of temperature also differs in the two areas, 1°F. in July to 18°F. in December at the former place, and 9°F. in July to 28°F. in December at the latter. Relative humidity varies from 58% in December, which is the driest month to 84% in August, which is the moistest month. The land and sea breezes alternate during the twenty four hours. The winds blow almost in all directions through the year, but the prevailing one is the south-west and west for nearly half the year including the monsoon season. The wind direction during winter changes to east and north-east, maintaining an ideal temperature of about 70°F., with January as the healthiest month in the year. The rainfall averages 9.5 inches at Manora and gradually reduces to 8 inches (average) at Drigh Road and 7 inches (average) further inland. This is really very meagre, and is also variable. There are years of great scarcity at times with only ½ an inch rain. The actual monsoon period is from the 9th. of July (commencement) to 23rd. of July (withdrawal). But the most striking feature of Karachi's climate is the cold and heat waves, as Karachi shares some of the eastern depressions coming from the Bay of Bengal and the western depressions from the Persian Gulf area. When

the weather becomes alternatively cold and hot, it is a stimulus to human life and activity. But the transition period between summer and winter or between spring and the monsoon season is treacherous and sickness is generally caused, especially throat and lung infections. On the whole, Karachi enjoys an ideal climate, especially during the winter season.

The Biological Environment: The location of Karachi being intermediate between tropical India and temperate Iran, both the plant and animal life is affected. Coastal types of algae, sea weeds and rose tangles grow in the littoral grounds. Fresh-water vegetation is found in the river-valleys and a few date-palms grow near some springs, though not so well as in the interior, due to the influence of the sea. Garden trees and fruit trees also thrive in the green belts of Karachi. Dry-hill vegetation is noticeable in the form of algaes, cactus, castor plant and certain rich medicinal plants. Even African trees grow well. The best part of Karachi in this respect is the Garden Quarter, in which numerous species can be found, the soil being derived from the old Lyari alluvium and the fresh water being near the surface. One remarkable feature of the Karachi gardens is that transplanation of some rich trees and creepers from foreign countries is possible.

Among the animal life, the donkey and the camel are naturally the most prominent beasts of burden. There are a number of poisonous snakes, lizards, jackals and hedge-hogs. Even crocodiles live in the fresh-water pools of Mangho Pir. Bird and insect life is typical of the semi-desert, and white ants are a menace to the house-wife and the book-lover. There are excellent fishing grounds near the Karachi coast, the chief favourable circumstances being the shallow continental shelf, clear sun-light and mingling of salt water and fresh water in the delta. River silts and sea weeds supply rich plankton, and there are favourable seasonal ocean currents too. Shoals of edible

fish are harboured not very far from the coast. There is a good trade of salmons, pomfrets, Bombay ducks, sardines, etc. Prawns are a speciality of Karachi and are worth canning and exporting. Thousands of fishermen find their living here. In these days of scarcity of protein food, the Karachi fish are a blessing to the people.

Lovers of hunting will find in the neighbouring hills some games like foxes, wild hogs, deer and even panthers in the far-off Kirthar range, small games in water tanks and diving birds in the harbour areas along the coast. Near Gadab, a village about 25 miles to the east of Mangho Pir, the sandgrouse, hill goat, partridge and rabbit are found. Crocodiles are common in the pools of the Hab river, in which there are large fish like *Mahseer*, weighing 20 to 30 pounds. In the Moach plain, north-east of Mauripur, there lives the Indian Bustare *(Taloor)*, a species of wild turkey; while at Malir, Landhi and Dabeji, the sandgrouse and partridge thrive. Ducks can be gathered at Korangi creek. Fowls in sweet-water pools are of the mallard, pintail and pochard varieties, which are quite edible, but those found in salt water lakes *(Dhands)* are unpalatable and taste like fish.

The Karachi cattle are exceptionally good, a hardy and enduring type of milch cattle, which are exported to far-off places like Manila. Buffaloes are not very common, and milk supplied to Karachi is generally cow's milk, which is tolerably good.

Amidst such an environment, the people who come to settle down in the City from far and near, find life congenial and worth living on the whole.

Again, students of geology, geography, geophysics, natural science and history - all will consider Karachi to be a University

in itself, affording scope for practical field work at every step. Although borings for petroleum deposits have so far not been successful - e. g., the Drigh Road dome boring carried to about 1,800 feet - , suitable structures do exist within the Karachi environs.

THE PEOPLES OF KARACHI.

Though the Karachi coast is not so inviting due to the growing Indus delta, there have been frequent inroads of peoples from the sea as well as the interior. Karachi has attracted thousands of peoples of different castes and creeds at different times. From the west, the Arab and Iranian trade routes, from the north the navigable Indus river, from the east the numerous camel paths, and from the south the harbour have helped immigration throughout the century, and there have been but few chances of emigration because of the flourishing condition of the harbour. Most of the settlers have stayed long, if not for good. Though it is a transit city, no doubt the profits have been so great that the people have found it necessary to stay on more or less permanently. On the inception of Pakistan, Karachi attained the status of Federal Capital of Pakistan, and combined with the factors of its being a flourishing port and the principal commercial centre, the number of immigrants has tremendously increased. The rising industries are a new attraction for the immigrants.

Population Pattern - pre-Partition and post-Partition : To-day Karachi has become all the more a city of varying cultures and a teeming population, which is ever on the increase. In pre-partition days, the composition of the population was different from what it is now. Hindus were in a majority, while now due to the exodus of the Hindus, Muslims far outnumber any other community.

The Hindus : The Hindus were the original inhabitants

and maintained a stable majority for long. The city's trade was mostly in their hands. Some of them came from adjacent parts of the Punjab, from the desert parts of Rajputana and also from Cutch, Kathiawar and Gujrat as traders, merchants and shopkeepers. Most of them were conservative, caste-ridden and would not inter-marry. These Hindus had their castes of different kinds, - the Brahmans or the priestly class, but here mostly engaged in trade; the Kshatriyas engaged in the fighting forces, represented by the Marahtta Soldiers and the policemen; the Vaishyas, or the Lohanas, sub-divided into the *Amils*, as officers, pleaders, etc., and the *Diwans* or Government servants, and the non-*Amils*, as merchants and agriculturists. The *Bhai Bandh* community of merchants, again, have been well-known as dealers in cotton and grain. The Jats, or the old scythians, have lived only as breeders of camel and cattle. With the extention of the city limits the more well-to-do migrated from the congested areas to specially built colonies in the north. As a result of the partition, Hindus have pratically all left Karachi. The 1951 census showed only 0.4% of them in the city.

The Parsees: Among the minority communities, there are the Parsees, the followers of the Iranian Prophet Zoroaster. They came to Karachi as businessmen and traders with the British army in the commissariat department. They have had a brilliant history in India and are known for business acumen, honesty of purpose and cosmopolitan charities. This lucky city soon made them prosperous, particularly as *Dubashes* in the business of loading and unloading the numerous ships that came to the shore. A very large part of Karachi has been built by them in the Saddar Bazaar and Civil Lines area. By dint of hard labour and by progressive methods, they have maintained a high standard of living and kept up the prestige of their forefathers of Iran and of Bombay. Some of the industries in Karachi were also established by the older generation, who again laid the foundation of their own colonies and public institu-

tions, *Chawls*, industrial schools and hospitals. The Parsees have thus to a great extent relieved the Government of the burden of life in the city. But the present generation needs a revolution in its socio-economic structure, in order that they may play a similar part in the future progress of Pakistan.

The Parsee *Panchayatwadi* in the Ranchore Quarters for the poor class and the Katrak Parsee Colony for the middle class, are the main Parsee localities, although there are many families still living in crowded Saddar Bazaar and Civil Lines Quarters in scattered flats and bungalows. Their total strength in Karachi hardly exceeds 5,000 according to 1951 census. After the partition it appears that many Parsees have migrated to Karachi from Bombay and other centres in search of business or service, but they have to face the housing problem, alongwith other immigrants.

The Christians: The Christians, nearly 20,000 in number, also have been helpful with their share in the public services and peaceful pursuits. The religious zeal of the Catholic community is well known. The Goans, mostly Roman Catholics, are known for their ability and enterprise in Karachi. Like the Parsees, they have also their own religious and secular institutions established by them in the city. Inter-marriages of Europeans with the Indians on the west-coast of India have resulted in a certain number of Anglo-Indians living in the city. They have now made Pakistan their permanent home, yet maintaining frequent contacts with their homelands because of the quick and comfortable transports available in recent years. There are some permanent domiciled Europeans, specially trained men and women with a higher standard of life and giving a certain amount of occidental dignity to the city. Britishers are still in some of the Pakistan services. There are business firms and industries maintained by other Europeans. Their enterprise benefits not only themselves but also the other inhabitants of the city.

They have their own Chamber of Commerce, their Schools and churches, and are, on the whole, prosperous. The establishment of several foreign Embassies in Karachi have added to the number of the Christians. The native Christians mostly live in Saddar Bazaar around the Catholic Church. A Garden Colony, called the Cincinnatus Town, has been established for the middle class, while the Europeans and other foreigners generally live in Frere Town, Bath Island and Clifton.

Other minority communities : Other minority communities are the Jews and the Jains. The Sikhs were a notable minority too, but they have all migrated to India after the partition.

The Muslims : The Muslims, up to August 1947, found themselves actually in a minority in the city, so great was the influx of Hindus from every side. In a province with a decidedly large Muslim majority, it was indeed an anomaly. But after the exodus of the Hindus, they have attained a most powerful majority. They now form more than 90% of the population of the city. Formerly the Hindus were found in the heart of the city and held a leading place in its corporate life but now the position is different. Muslims are now in the forefront of Karachi's population and its future is largely in their hands. They are gradually getting more and more educated. Due to the historical incidences and the political changes in the past, several of the Muslim settlers in the Karachi area were from Iran, Afghanistan, Baluchistan, Makran, Arabia and Africa. Many natives embraced Islam at the time of the Arab conquest of Sind and there have been Hindu converts to Islam also from Cutch, Kathiawar and Gujrat, still speaking the Gujrati language. There are the Khojas, the Lohanas, the Borahs and the Memons, all doing well in their own special lines and trades. Many more are engaged in industries, such as fishery, gardening, cattle and camel breeding, etc. Several wealthy Muslims have purchased properties left by the Hindus in Saddar Bazaar, Civil Lines, Bunder Road Extension, and have

built and are building beautiful new colonies of their own. This is the upper class of refugees, who have resettled themselves in a short time in the Karachi area.

The Refugees : The Muslim refugees from India have transfused new blood into the heart of the city. There have been two prominent streams, - one from the sea-side, Bombay, Gujrat, Cutch, Kathiawar and even from far-off Hyderabad, and the other from East Punjab, Delhi, U. P., Bihar etc., - from beyond the Indo-Pakistan borderland, driven here in desperation and unsettled in their minds and their homes. The refugee population is now estimated at over one million. Many are found in divided families, their relatives still living in India. Society seems to be in a state of flux here to day. Many originally belonged to the rural population but are now forced to live their life in a city like this. Businessmen from various parts of India have already ably replaced the Hindus, but the problem of the *Muhajireen* is acute in the city. Many of them are found homeless. Even women are found cooking in temporary huts on the road side. Children lie in dust and squalor and the old people are sick and helpless. With their miserable wherewithals they lie in patchwork tents on the foot-paths and in road-side huts, but they are very skilful in small handicrafts, which are frequently exhibited in their tiny improvised shops. It is expected that some of the small trades and industries will soon go into their hands. What they badly need is multi-purpose Co-operative Credit Societies. To resettle these refugees, new colonies, e. g., Bihar Colony, Pir Illahi Bakhsh Colony, Nazimabad, Drigh Village, Malir and Landhi colonies have been built. Housing Societies have been formed and serious rehabilitation is being carried on. There is over-crowding everywhere. It is not likely that all the surplus population can be absorbed by the city, which already seems to have reached its saturation point. Urdu is gradually coming to its own alongside English and Sindhi and other languages, and life around is taking more and more obvi-

ous and emphatic Islamic complexion From this great conflict of cultures belonging to the different communities, a new civilization - that of differing religions and sects living in complete amity, mutual tolerance and good-will - is likely to emerge all the stronger in Karachi. For long years Karachi has been a miniature Sind; now with its new position as the leading city of Pakistan, its character is changing and a New Karachi being Pakistan in miniature is in sight.

That these refugees are going to be an asset of Pakistan can never be denied. Such immigrants in other countries of the world have caused a rejuvenation of industries and a rebirth of learning besides, e. g., U. S. A., Latin America, Turkey, and Iran. Let us hope and pray that refugees, locals and all live for Pakistan first and last; for, isolated and exclusive strivings have built up countries and nations never.

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